

University
of Toronto

Calendar 1976-1977

**Faculty of
Applied Science
and Engineering**

Sesquicentennial



1827-1977



Digitized by the Internet Archive
in 2015

University
of Toronto

Faculty of
Applied Science
and Engineering

Calendar 1976-1977

University of Toronto Press
1976

I	Calendar	5
II	The Faculty of Applied Science and Engineering	7
III	Departments and Divisions of the Faculty	
	First Year Studies	11
	Civil Engineering	12
	Geological Engineering and Applied Earth Science	14
	Mechanical Engineering	16
	Industrial Engineering	18
	Engineering Science	20
	Chemical Engineering and Applied Chemistry	21
	Electrical Engineering	24
	Metallurgy and Materials Science	27
IV	Centres and Institutes	
	Institute for Aerospace Studies	29
	Institute of Biomedical Engineering	31
	Cockburn Centre for Engineering Design	32
	Computer Systems Research Group	33
	Institute for Environmental Studies	33
	Centre for the Study of Materials	34
	Systems Building Centre	34
V	Professors Emeriti	36
VI	Administrative Offices of the University	38
VII	General Information: Admissions, Student Services	40
VIII	Scholarships, Bursaries, Medals and Prizes	48
IX	Fees and Expenses	84
X	Academic Regulations	86
XI	Program Specifications and Course Outlines	95
XII	Index of Contents	216

CALENDAR

1976

January	February	March	April
S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
May	June	July	August
S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
September	October	November	December
S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

CALENDAR

1977

January	February	March	April
S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
May	June	July	August
S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
September	October	November	December
S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

FALL TERM, 1976

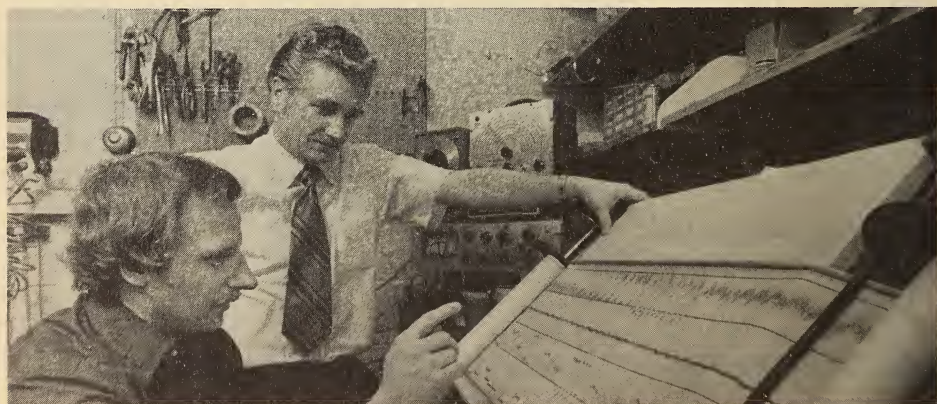
August 30	Monday	
to		
September 3	Friday	Enrollment period for students who have not already pre-registered.
September 6	Monday	Labour Day. Buildings closed.
September 7	Tuesday	Orientation program for First Year students.
September 8	Wednesday	Lectures and laboratory work commence at 9:00 a.m.
September 24	Friday	Last day for students to add or substitute Fall Term courses (including Fall Term courses taken in the Faculty of Arts and Science.)
October 1	Friday	Last day to add or substitute Full Year courses taken in the Faculty of Arts and Science.
October 11	Monday	Thanksgiving Day. Buildings closed.
October 22	Friday	Last day for students to drop a Fall Term course without academic penalty (including Fall Term courses taken in the Faculty of Arts and Science.)
October 28	Thursday	Meeting of Faculty Council.
November 12	Friday	Last date for withdrawal from the Fall Term without academic penalty.
December 7	Tuesday	Last day of lectures in Fall Term. All term work should be submitted by this date.
December 9	Thursday	
to		Study and examinations in Fall Term courses.
December 22	Wednesday	
December 25	Saturday	Christmas Day. Buildings closed.

SPRING TERM, 1977

January 1	Saturday	New Year's Day. Buildings closed.
-----------	----------	-----------------------------------

January 10	Monday	Lectures and Laboratory work commence at 9:00 a.m.*
January 14	Friday	Last day for students to add or substitute Spring Term courses taken in the Faculty of Arts and Science.
January 21	Friday	Last day for students to add or substitute Spring Term courses taken in the Faculty of Applied Science and Engineering. Last day to drop a full year course without academic penalty and without credit.
January 26	Wednesday	Meeting of Faculty Council.
February 25	Friday	Last day for students to drop a Spring Term course without academic penalty (including Spring Term courses taken in the Faculty of Arts and Science).
March 18	Friday	Last date for students to withdraw from the Spring Term without academic penalty.
April 7	Thursday	Last day of lectures in Spring Term. All term work should be submitted by this date.
April 8	Friday	Good Friday. Buildings closed.
April 11	Monday	Study and examinations in Spring Term courses
to		
April 22	Friday	Meeting of Faculty Council.
May 24	Tuesday	

*Students whose programs include Arts and Science courses are reminded that Spring Term lectures in the Faculty of Arts and Science commence on Monday, January 3.



ADMINISTRATIVE STAFF

Dean: B. Etkin, B.A.SC., M.A.SC., D.ENG., F.A.I.A.A., F.C.A.S.I., F.R.S.C., P.ENG.

Associate Deans: P. I. P. Boulton, B.A.SC., M.A.SC., PH.D., P.ENG.

R. E. Jervis, M.A., PH.D., P.ENG.

Assistant Dean: M. J. S. Leitch, B.ARCH., F.R.A.I.C., P.ENG.

Assistant Dean and Secretary: J. A. Gow, B.A.SC., P.ENG.

Assistant Secretary: B. M. Leathem, B.A.SC., P.ENG.

Faculty Registrar: C. E. Rickards, B.A.SC., P.ENG.

Supervisor of Student Services: Jean K. Madill, B.SC.

The Faculty of Applied Science and Engineering in the University of Toronto offers a very wide range of undergraduate and post-graduate studies in engineering. Students may qualify for the Bachelor of Applied Science Degree (B.A.Sc.) in any one of eight programs: Civil Engineering; Geological Engineering and Applied Earth Science; Mechanical Engineering; Industrial Engineering; Engineering Science; Chemical Engineering; Electrical Engineering; Metallurgy and Materials Science. Within these programs there are many electives and options. In the Geological Engineering program, students can specialize in Mineral Exploration, Mineral Engineering or Geotechnical Engineering. In the Engineering Science program, students can in their final two years take one of the options: Aerospace; Chemical; Computer Science; Electrical; Geophysics; Materials Science; Nuclear and Thermal Power; Physics. Thus, an engineering student can specialize in virtually any significant branch of modern technology. Admission standards in the First Year curriculum are common to all programs except Engineering Science. Admission to the latter is restricted to High School graduates with substantially better than minimum qualifications, and the First Year curriculum in that program is more demanding both in level and in pace.

The bulk of the teaching of undergraduate students in engineering is provided by the six departments of the Faculty (which altogether comprise about 180 professors): Civil Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, Metallurgy and Materials Science. Additionally, undergraduate

teaching is provided by the Institute for Aerospace Studies (an Institute of this Faculty) and the Institute of Biomedical Engineering (an Institute in both this Faculty and the Faculty of Medicine).

The Faculty is most fortunate in being part of a great university, and consequently has available to it the resources of other Divisions, upon which it draws to great advantage. The Departments of Geology, Mathematics, Computer Science, Physics, English, History, Philosophy, and Political Economy, all in the Faculty of Arts and Science, make contributions to the engineering curriculum which greatly enrich it.

Beyond the undergraduate level, the Faculty has a strong commitment to graduate studies and research. Graduate programs leading to the M.Eng., M.A.Sc., and Ph.D. degrees are offered through the School of Graduate Studies by each of the six departments and two institutes previously mentioned. The staff of the Faculty also contributes at the graduate level to the programs of several other centres and institutes in the areas of urban planning, transportation, environmental studies and history of technology. This remarkable pattern of bridges linking the arts, sciences and professions in studies of man, his ideas and his work, lends a distinctive vitality and range to engineering at Toronto.

Since its founding in 1873, the School of Practical Science at the University of Toronto, which became the Faculty of Applied Science and Engineering in 1906, has conferred more than 18,000 degrees and diplomas. Of the 16,000 living graduates, 6,300 reside in Metropolitan Toronto, a further 5,700 in other communities throughout Ontario and 2,000 in other provinces in Canada. Another 1,500 are living in the United States and more than 500 in other areas of the world, including Africa, Asia, Europe, South America, Central America and Mexico, Oceania and the West Indies.

These graduates have pursued diverse careers in all fields of engineering: in the resource industries, manufacturing, transportation, communications; in law, finance and health care systems. They are employed by governments from the municipal to the federal level, in private enterprise, both large and small, and throughout our educational system.

Currently there are some 2,400 undergraduate and 550 postgraduate students. An important historical point for students is that the Engineering Society, with its "Cannon" and "LGMB" is the oldest engineering organization of any formal kind in Canada.

The Faculty is located on the main campus in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall and on the east by Taddle Creek Road where in the days of Canadian Confederation there was indeed a creek so named.

The administrative offices are located in the southwest corner of the Galbraith Building at 35 St. George Street. Students and visitors may obtain information and assistance here.

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applied Science:

- Civil Engineering (Program 1)
- Geological Engineering and Applied Earth Science (Program 2)
 - Mineral Exploration (Option 2A)
 - Mineral Engineering (Option 2B)
 - Geotechnical Engineering (Option 2C)
- Mechanical Engineering (Program 3)
- Industrial Engineering (Program 4)
- Engineering Science (Program 5)
 - Aerospace (Option 5a)
 - Chemical (Option 5c)
 - Computer Science (Option 5cs)
 - Electrical (Option 5e)
 - Geophysics (Option 5g)
 - Materials Science (Option 5m)
 - Nuclear and Thermal Power (Option 5nt)
 - Physics (Option 5p)
- Chemical Engineering (Program 6)
- Electrical Engineering (Program 7)
- Metallurgy and Materials Science (Program 8)

The curricula of the various programs are set out in detail in Section XI. The regulations for standing and promotion are given in Section X.

PART-TIME STUDY – WOODSWORTH COLLEGE

The first two years of all engineering programs except Engineering Science are also offered through Woodsworth College for students interested in part-time study. The First Year program is available in both day-time and evenings, the Second Year in day-time only. As there is no provision for part-time study in engineering beyond the Second Year, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding Part-Time Study may be obtained from the Degree Courses Section, Woodsworth College, 119 St. George Street, University of Toronto, Toronto M5S 1A1:

GRADUATE STUDY AND RESEARCH

Facilities available in the Departments of the Faculty for postgraduate study and research leading to the degrees of Master of Engineering (M.Eng), Master of Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.) are described in Section III. For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Persons desiring to enroll as Special Students (not proceeding to the degree) should consult the Secretary of the Faculty regarding admission requirements and the procedure for application.

INTERIM HIGH SCHOOL ASSISTANTS' CERTIFICATE TYPE A

Graduates of engineering programs may be admitted to Type A certificate courses at The Faculty of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the Faculty of Education may be eligible for admission to the Type B course and later for endorsement of the Type B certificate.

Inquiries regarding admission to the Type B course should be addressed to the Registrar, Faculty of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should be addressed to the Director, Committee on Advanced Standing, Faculty of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various provincial associations of Professional Engineers, in accordance with their individual policies.

SUMMARY OF STUDENTS IN ATTENDANCE – *Session 1975–76*

PROGRAM		1	2	3	4	5	6	7	8	TOTAL
Year	I	107	29	90	51	148	102	110	17	654
	II	126	37	116	77	91	115	125	14	701
	III	104	22	92	63	71	75	117	15	559
	IV	100	21	77	43	75	40	98	12	466
TOTAL										2380

DIVISION OF FIRST YEAR STUDIES

Chairman of First Year Studies:

P. I. P. Boulton

Coordinating Staff:

K. G. Balmain, Department of Electrical Engineering
E. J. Barbeau, Department of Mathematics
E. P. Botta, Department of Mathematics
W. H. Burgess, Department of Chemical Engineering
C. H. Chapman, Department of Physics
I. G. Currie, Department of Mechanical Engineering
I. R. Graham, Department of Mathematics
J. N. P. Hume, Department of Computer Science
H. Kunov, Department of Electrical Engineering
W. A. Miller, Department of Metallurgy and Materials Science
R. H. Mills, Department of Civil Engineering
S. Pasupathy, Department of Electrical Engineering
R. A. Ross, Department of Mathematics
S. Sandler, Department of Chemical Engineering
B. P. Stoicheff, Department of Physics
S. D. Scott, Department of Geology
J. Timusk, Department of Civil Engineering
S. M. Uzumeri, Department of Civil Engineering
J. R. Vanstone, Department of Mathematics
R. T. Woodhams, Department of Chemical Engineering

In his first year of studies, an engineering student must establish a strong foundation in the basic disciplines which underlie the whole field of Engineering. The First Year program has been designed to this end, providing for courses in mathematics and in the physical.

chemical and engineering sciences. In addition, the student is given an opportunity to broaden his education and outlook through the Non-Technical Electives. There are two First Year curricula: Engineering, the standard curriculum; and Engineering Science, the enriched curriculum.

The Engineering Science curriculum is designed for students who intend to continue in one of the following options in Third Year: Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power, and Physics. The curriculum is demanding and admission to First Year Engineering Science is granted only to those students with better than average ability in mathematics and the sciences. Students undertaking this curriculum must maintain satisfactory term and year averages in their first year work in order to pursue the Engineering Science program in their second year. Transfers from Engineering Science to other programs are permitted, subject to the Academic Regulations (Section IX), for students in good standing at the end of the first term or the first year.

The Engineering curriculum is designed for students who intend to continue in one of the following programs in Second Year: Civil Engineering, Geological Engineering and Applied Earth Science, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, and Metallurgy and Materials Science. Students must elect one of these programs on entering the First Year, and this election guarantees a place in that program in Second and subsequent years, subject to maintenance of satisfactory standing. Subject to the availability of places, a student who successfully completes the First Year in one of the above programs may request to transfer to any other of these programs. Because of the special nature of the Engineering Science curriculum, transfers from these programs to Engineering Science are not possible except in extraordinary cases.

Students wishing to transfer to a different program at the end of First Year should make application to the Faculty Office not later than July 1.

DEPARTMENT OF CIVIL ENGINEERING

Professor and Chairman of the Department:

G. W. Heinke, B.A.SC., M.A.SC., PH.D.(McM.), P.ENG.

Associate Professor and Associate Chairman of the Department:

G. T. Will, B.A.SC., M.A.SC., P.ENG.

Professors:

F. A. DeLory, B.ENG.(McG.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.), P.ENG.

J. Ganczarczyk, M.SC., D.SC.(GLIWICE), D.SC.(WARSAW), F.R.S.H., P.ENG.

M. W. Huggins, B.A.SC., M.A.SC., F.E.I.C., F.A.S.C.E., P.ENG.

P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.), P.ENG.

T. C. Kenney, B.ENG.(McG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), P.ENG.

R. H. Mills, B.SC.(WITWATERSRAND), F.I.C.E.
 J. Schwaighofer, DIP.ING.(GRAZ), M.S.(PENN.ST.), PH.D.(PENN.ST.), DR.TECH.(GRAZ),
 P.ENG.
 R. M. Soberman, B.SC.(DAL.), PH.D.(M.I.T.), P.ENG.
 S. M. Uzumeri, B.A.SC., M.A.SC., P.ENG.

Visiting Professors:

P. Gergely, PH.D.(ILL.)

Associate Professors:

J. D. Barber, B.A.SC., M.A.SC., P.ENG.
 P. C. Birkemoe, B.SC.E., M.S.C.E.(PURDUE), PH.D.(ILL.), P.ENG.
 M. P. Collins, B.E.(CANTERBURY), PH.D.(N.S.W.), P.ENG.
 R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.), P.ENG.
 A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC., F.E.I.C., P.ENG.
 M. M. Davis, B.SC.,(QU.), M.SC.(PURDUE), P.ENG.
 E. Hauer, B.SC., M.SC.(TECHNION), PH.D.(CALIF.), P.ENG.
 B. J. Haynes, B.A.SC., P.ENG.
 J. G. Henry, B.SC.(QU), M.S.E.(PRINCETON), PH.D., P.ENG.
 V. F. Hurdle, B.S.(CALIF.), M.ENG.(CALIF.), PH.D.(CALIF.), P.E.(CALIF.).
 H. L. Macklin, B.A.SC., F.E.I.C., P.ENG.
 V. R. Riley, B.A.SC., PH.D.(CANTAB), P.ENG.
 E. I. Robinsky, B.A.(BEIRUT), B.SC.(BEIRUT), M.S.(HARVARD), PH.D., P.ENG.
 K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.), P.ENG.
 G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.(CALIF.), P.ENG.
 J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.), P.ENG.
 J. Vlcek, B.SC.F.(N.B.), M.A.SC., D.SC.(BRATISLAVA), P.ENG.
 P. M. Wright, B.E., M.SC.(SASK.), PH.D.(COLO.), P.ENG.

Assistant Professors:

B. J. Adams, B.SC.(MAN.), M.S.(NORTHWEST), PH.D.(NORTHWEST), P.ENG.
 P. H. Byer, S.B.(M.I.T.), S.M.(M.I.T.), PH.D.(M.I.T.)
 E. Kuhn, DIP.ING.(BRATISLAVA), M.A.SC., P.ENG.
 S. Otani, B.ENG.(TOKYO), M.S.(ILL.), PH.D.(ILL.)
 R. G. Rice, B.A.SC., S.M.(M.I.T.), PH.D., P.ENG.
 J.-C. Roegiers, DIP.ING.(LIEGE), PH.D.(MINN.), P.ENG.

Adjunct Professors:

R. D. Foster, M.A.SC., P.ENG.
 E. Koczur, B.SC.(QU.), M.A.SC., PH.D., P.ENG.
 J. D. Morton, B.SC.(DURHAM), D.I.C.(IMP.), M.ENG., P.ENG.
 P. E. Wisner, DIPL.ING.(BUCHAREST), PH.D.(BRNO), P.ENG.

UNDERGRADUATE PROGRAM IN CIVIL ENGINEERING (Program 1)

Civil Engineering as a profession is concerned with improving man's environment through the planning, designing and construction of facilities such as dams, buildings, transportation systems and municipal services. These activities encompass a very wide range of knowledge and this in turn creates special curriculum problems.

The program in Civil Engineering is arranged so that a student may undertake either a relatively broad study of the discipline or a more comprehensive examination of one of its principal fields (structural, municipal and sanitary, transportation, geotechnical, and surveying). This flexibility is derived from the fact that a Fourth Year student's program consists mainly of elective courses and a thesis. The departmental electives are time-tabled so as to maximize the freedom of students to take the electives of their choice. Several project-oriented courses provide students with an understanding of the engineering approach to planning and design.

In summary, the program is designed to develop well-informed creative engineers possessing innovative and directive capabilities.

GRADUATE PROGRAMS IN CIVIL ENGINEERING

Qualified candidates are accepted for advanced studies in geodesy, geotechnical engineering, photogrammetry, remote sensing, sanitary and environmental engineering, structural engineering, transportation engineering and hydraulic engineering. The last is a cooperative program with the Department of Mechanical Engineering.

Additional information can be obtained by writing to the Department of Civil Engineering for a copy of the Graduate Brochure.

DIVISION OF GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

Chairman of the Division:

F. A. DeLory, B.ENG.(McG.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.), P.ENG., *Professor of Civil Engineering*

Faculty Members of the Division:

D. H. Gorman, B.SC.(U.N.B.), PH.D., *Associate Professor of Geology*

G. W. Heinke, B.A.SC., M.A.SC., PH.D.(McM.), P.ENG., *Professor and Chairman, Department of Civil Engineering*

T. C. Kenney, B.ENG.(McG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), P.ENG., *Professor of Civil Engineering*

R. T. McAndrew, B.SC., M.SC.(QU.), PH.D.(U.B.C.), P.ENG., *Associate Professor of Metallurgy and Materials Science*

A. J. Naldrett, B.A.(CANTAB.), M.SC.(QU.), PH.D.(QU.), *Professor of Geology*

H. U. Ross, C.D., M.SC.(McG.), P.ENG., *Professor of Metallurgical Engineering*
S. D. Scott, B.SC., M.SC.(U.W.O.), PH.D.(PENN.ST.), *Associate Professor of Geology*
D. W. Strangway, M.A., PH.D., F.R.S.C., *Professor and Chairman, Department of Geology*

Visiting Professor:

S. W. Holmes, B.SC.(McG.), M.SC.(McG.), PH.D.(CORNELL)

UNDERGRADUATE PROGRAM IN GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (Program 2)

Geological Engineering and Applied Earth Science is an interdisciplinary program that emphasizes the engineering application of earth science to professional activities related to the materials of the earth. The range of activities involved includes exploration for energy and mineral resources, development and control of the methods of removing minerals from the earth and of processing minerals to yield metals, protection of the environment in the development of earth materials, and geotechnical problems involved in construction with earth materials. Geological Engineering might be summarized as: The combination of the science of geology with the principles of engineering in the use of materials of the earth for the convenience of man in compatibility with the environment.

The program is an interfaculty one for which the specialized core of geological study is provided by the Department of Geology (Faculty of Arts and Science) while several departments in the Faculty of Applied Science and Engineering, particularly the Department of Civil Engineering and the Department of Metallurgy and Materials Science, contribute instruction in Engineering subjects. The First Year of the four year program is the Engineering curriculum. The Second Year is unique to the Geological Engineering and Applied Earth Science program and emphasizes training in geology, mathematics, basic and material science and acquaints students with the areas of professional activity in the various fields of Geological Engineering. For the Third and Fourth years, students choose one of the three options listed below.

Option A, Mineral Exploration, involves the application of geological (and geophysical and geochemical) principles to the discovery and evaluation of ore deposits. Over the first three years, students are given a thorough grounding in basic geology, including mineralogy, petrology, structure and stratigraphy. In their fourth year, and to some extent during their third, students take more practical courses including Ore Deposit Evaluation, Exploration Geophysics, Petroleum Geology, Mineral Deposits and Exploration Geochemistry. The last three courses are taken together with Arts and Science students, but in the last two, special laboratories and projects devoted to ore deposit evaluation are given in the mineral exploration option. The overall aim of the option is to expose students to the specialized knowledge that they will require to be effective in the mining industry, while at the same time giving them the background of a well-trained geologist.

Option B, Mineral Engineering, which is concerned with the concentration and processing of the valuable contents of the products of mining operations, emphasizes mineralogy in addition to basic physics and chemistry. Specialized courses in mineral beneficiation, extractive metallurgy, surface chemistry and process design are offered in the third and fourth years of the program.

Option C, Geotechnical Engineering represents the area relating Geology to Civil Engineering, particularly to construction in or of earth materials. The last two years of the program concentrate on the engineering and mechanical properties of earth materials, both rock and soil, and their use as support for structures, as with foundations or as the material of the structure itself, as in dams and tunnels. Civil Engineering courses are included so that the Geotechnical Engineer has a knowledge of structural design, foundations and fluid mechanics. Training is provided to qualify students to identify geological hazards affecting the design and safety of specific engineering projects in or on natural materials. As the engineer has relatively little control over the natural earth materials of construction (e.g. rock, gravel, sand, clay) compared with the man-made materials (e.g. concrete and steel), the program emphasizes recognition, determination and improvement of the material properties.

DEPARTMENT OF MECHANICAL ENGINEERING

Professor and Chairman of the Department:

D. S. Scott, B.SC.(QUEEN'S), M.SC.(QUEEN'S), PH.D.(NORTHWESTERN), P.ENG.

Associate Professor and Associate Chairman:

D. McCammond, B.SC.(QU.BELFAST), PH.D.(QU.BELFAST), P.ENG.

Professors:

W. D. Baines, B.SC.(ALTA.), M.S., PH.D.(IOWA), P.ENG.

F. C. Hooper, B.A.SC., D.I.C.(IMP.COLL.), P.ENG.

J. F. Keffer, B.A.SC., M.A.SC., PH.D., P.ENG.

H. J. Leutheusser, DIPL.ING.(KARLSRUHE), M.A.SC., PH.D., P.ENG.

A. W. Neumann, B.A., DR.RER.NAT.(MAINZ)

F. P. J. Rimrott, DIPL.ING.(KARLSRUHE), M.A.SC., PH.D.(PENN.STATE), DR.ING.(DARMSTADT), P.ENG.

I. W. Smith, B.A.SC., M.A.SC., P.ENG.

J. Vande Vegte, DIPL.ING.(DELFT), M.A.SC., PH.D., P.ENG.

Associate Professors:

A. H. Abdelmessih, B.M.E.(CAIRO), M.S.(OKLAHOMA STATE), PH.D., P.ENG.

A. B. Allan, B.A.SC., M.A.SC., P.ENG.

D. L. Allen, B.SC.(DAL.), B.E.(N.S.TECH.), M.A.SC., PH.D., P.ENG.

I. G. Currie, B.SC.(STRATHCLYDE), M.A.SC.(B.C.), PH.D.(CAL.I.T.), P.ENG.
R. G. Fenton, DIPL.ING.(BUD.), PH.D.(N.S.W.), P.ENG.
D. F. James, B.SC.(QUEEN'S), M.S.(CAL.TECH.), PH.D.(CAL.TECH.), M.A.(CANTAB),
P.ENG.
B. Tabarrok, B.SC.(WOLVER.&STAFF.), D.PHIL.(OXON), P.ENG.
C. A. Ward, B.SC.(TEX.), PH.D.(NORTHWEST.), P.ENG.

Assistant Professors:

D. B. Cherchas, B.A.SC.(U.B.C.), M.A.SC., PH.D., P.ENG.
R. C. Flanagan, B.SC., M.E.(U.N.B.), PH.D.(U.B.C.), P.ENG.
W. W. Martin, B.A.SC., M.S.(CAL.TECH.), DR.ING.(KARLSRUHE)
R. D. Venter, B.SC.(WITWATER.), M.ENG.(McM.), PH.D.(McM.)

UNDERGRADUATE PROGRAM IN MECHANICAL ENGINEERING (Program 3)

The discipline of Mechanical Engineering has developed from the construction of machines beneficial to man. Now, however, the science embraces much more than the basic design, fabrication and operation of these machines. The student in Mechanical Engineering develops a broad expertise through background training in applied mechanics, thermodynamics, fluid mechanics, control theory and material science, which are all studies of the physical principles on which the machines are based. In addition he receives analytical training in mathematics to provide the means of interrelating the physical phenomenon and operational concepts. All of the specialities meet in the design process which is taught through the use of projects. One develops the thinking process by which new devices are conceived through the design and fabrication of original machines. It is here that the student must also learn to appreciate social implications of engineering such as concern for the environment, conservation of energy and the economic consequences of his creation.

Virtually the whole spectrum of primary and secondary industries seeks the practising Mechanical Engineer as an employee or a consultant. The largest concentrations are found in the primary power production industry where hydraulic, thermal, and nuclear energy is converted to electricity; in the manufacture of automobiles, aircraft and other mass transportation equipment; in the heating and air-conditioning industry where the environmental control of buildings is established; and in the primary metal producing industries. Some Mechanical Engineers are associated with smaller organizations such as those in the medical equipment and noise control fields, in the management of large and small industries and in education.

The Second and most of the Third Year curriculum in the course is devoted to background studies. Design laboratories are introduced later in the Third Year and carried on throughout the Fourth Year. At the same time, the student can choose electives to suit his talents and inclinations. He can sharpen his understanding of the fundamentals

in preparation for graduate work, for employment in research and development areas, or he can concentrate on groups of subjects leading to association with specific industries, such as central power station design or environmental control.

GRADUATE PROGRAMS IN MECHANICAL ENGINEERING

For students intending to specialize in a discipline of Mechanical Engineering, the graduate Department offers the degree of Master of Engineering (M.Eng.), Master of Applied Science (M.A.Sc) and Doctor of Philosophy (Ph.D.). The M.Eng. is also offered on a part-time basis and is thus particularly suitable for engineers-in-training in industry. Admission into the graduate program is normally granted graduates with honour standing. The programs offered include the specialist disciplines of the Mechanical Branch of the Association of Professional Engineers of Ontario. Qualified candidates are accepted for specialized study in many areas including: Fluid Mechanics and Hydraulics, Heat Transfer and Thermodynamics, Mechanics and Dynamics, Vibrations and Acoustics, Elasticity, Plasticity and Viscoelasticity, and research topics currently under investigation in the Department.

Additional information is contained in the Departmental Graduate Programs Booklet, which may be obtained at the Departmental Office.

DEPARTMENT OF INDUSTRIAL ENGINEERING

Professor and Chairman of the Department:

B. Bernholtz, M.A., PH.D.(CAL.TECH.), P.ENG.

Associate Professor and Assistant Department Chairman:

R. W. P. Anderson, M.A.SC., P.ENG.

Professors:

J. W. Abrams, A.B.(CALIF.), PH.D.(CALIF.), P.ENG.

P. J. Foley, M.A.(GLASGOW)

A. Kruger, B.A., PH.D.(M.I.T.)

J. W. Senders, A.B.(HARV.)

J. G. C. Templeton, B.A., A.M.(PRINC.), PH.D.(PRINC.), P.ENG.

Associate Professors:

J. Abrham, M.A.(CHARLES), PH.D.(CHARLES)

J. A. Buzacott, B.SC.(SYDNEY), B.E.(SYDNEY), M.SC.(BIRMINGHAM), PH.D.(BIRMINGHAM)

S. H. Cohn, M.A.

A. A. Cunningham, M.A.(OXFORD), PH.D.(ADELAIDE)

E. E. Pickett, B.A.SC., M.A., PH.D.

M. J. M. Posner, B.A.SC., PH.D., P.ENG.

I. B. Turksen, B.S.(PITTS.), M.S.(PITTS.), PH.D.(PITTS.), P.ENG.

Assistant Professor:

J. S. Rogers, B.SC.(DAL.), M.S.(STAN.), PH.D.(STAN.)

Special Lecturers (part-time):

J. P. Rives, B.SC.(OKLAHOMA), M.SC.(KANSAS), P.ENG.

R. E. L. Seal, M.SC.(BIRM.), P.ENG.

E. L. Vitalis, B.B.A.(MINN.), M.A.(MINN.)

UNDERGRADUATE PROGRAM IN INDUSTRIAL ENGINEERING (Program 4)

Industrial Engineering is concerned with the analysis, design, improvement and operation of integrated systems of people, materials, equipment and information. This discipline crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory, and human factors engineering constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the program in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including applied thermodynamics, electric science, mechanics of materials, materials science, and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

The curriculum in Industrial Engineering allows, but does not require, each student to take a Technical Elective outside the Department in each of Second, Third and fourth Years.

Students are urged to select their electives with care, in order to improve their general engineering education or their knowledge of an area in which they wish to specialize. A list of areas of concentration and corresponding recommended subjects is included in the Industrial Engineering handbook, available from the Departmental Office.

GRADUATE PROGRAMS IN INDUSTRIAL ENGINEERING

The Department of Industrial Engineering offers opportunities for graduate study and research in Human Factors Engineering, Operational Research/Management Science, Computers and Information Systems, Queueing Theory, Applied Statistics, Mathematical Programming, Production and Inventory Control, Engineering Economics Systems, Operational Research in Health Care Delivery, Environmental Sciences and Engineering Decision Theory. Programs offered lead to the M.Eng., M.A.Sc. and Ph.D. degrees.

DIVISION OF ENGINEERING SCIENCE

Chairman of the Division:

B. P. Stoicheff, B.A.SC., M.A., PH.D., F.R.S.C., F.R.S. (*Professor of Physics*)

Associate Chairman of the Division:

O. Trass, B.S.E.(PRINC.), SC.D.(M.I.T.), (*Professor of Chemical Engineering*)

Faculty Members of the Division:

K. G. Balmain, B.A.SC., M.S.(ILL.), PH.D.(ILL.), P.ENG. (*Professor of Electrical Engineering*)

R. M. Farquhar, M.A., PH.D., F.R.S.C. (*Professor and Associate Chairman of Physics*)

J. W. Rutter, B.A.SC., M.A., PH.D., P.ENG. (*Professor of Metallurgy and Materials Science*)

R. C. Tennyson, B.A.SC., M.A., PH.D., (*Associate Professor, Aerospace Studies*)

J. R. Vanstone, B.A., M.A., PH.D., (NATAL) (*Professor of Mathematics*)

Z. G. Vranesic, M.A.SC., PH.D., P.ENG. (*Associate Professor of Computer Science and Electrical Engineering*)

C. A. Ward, B.SC.(TEX.), PH.D.(NORTHWEST.), P.ENG. (*Associate Professor of Mechanical Engineering*)

UNDERGRADUATE PROGRAM IN ENGINEERING SCIENCE (Program 5)

The Engineering Science program is designed for students primarily interested in the application of science to modern technology who wish to prepare themselves for careers in applied research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in engineering, science and mathematics, and the majority of graduates from this program do proceed to graduate study. Students who graduate from this program and do not continue their studies are nevertheless well qualified to fill a variety of positions in industry, government and teaching.

The courses offered are of high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. For this reason, admission is granted only to those who have achieved high standing in their previous academic work, and continuation in the program requires a minimum of 60% at the end of the first term and 66% at the end of the second term. A student who does not meet these requirements will be permitted to transfer into another Engineering program, subject to the requirements and provisions of the Academic Regulations. A student who successfully completes the First Year in Engineering Science may transfer into any other program in the Faculty. (Thereafter, transfers into other programs in the Faculty can normally be made, subject to some program adjustments.)

The curricula for the first two years of the program are common for all students, with

some Technical Electives available in terms 1S and 2S. There are available eight carefully planned options* each of which provides a specialized preparation for a particular branch of applied science. In addition, students have the opportunity to select a program that does not conform to any one of the options, as outlined in Section XI.

DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

Professor and Chairman of the Department:

M. E. Charles, B.SC.(LOND.), M.SC., PH.D.(ALTA.), F.C.I.C., P.ENG.

Professor and Associate Chairman of the Department:

J. W. Smith, M.A.SC.(U.B.C.), PH.D.(LOND.), D.I.C.(IMP.COLL.), F.C.I.C., P.ENG.

Professors:

D. G. Andrews, M.A.(CANTAB.), F.I.MECH.E., P.ENG.

D. Basmadjian, DIP.ING.CHEM.(ZURICH), M.A.SC., PH.D., M.C.I.C., P.ENG.

W. H. Burgess, B.CH.E., M.F.S., PH.D.(CORN.), F.C.I.C., P.ENG.

W. F. Graydon, M.A.SC., PH.D.(MINN.), F.C.I.C., P.ENG.

R. L. Hummel, B.S.(PURDUE), PH.D.(IOWA), F.C.I.C., P.ENG.

R. E. Jervis, B.A., M.A., PH.D., F.C.I.C., F.I.A.F.S., P.ENG.

R. Luus, B.A.SC., M.A.SC., A.M., PH.D.(PRINCETON), F.C.I.C., P.ENG.

W. G. MacElhinney, B.A.SC., M.A.SC., F.C.I.C., P.ENG.

R. W. Missen, M.SC.(QU.), PH.D.(CANTAB.), F.C.I.C., P.ENG.

M. R. Piggott, B.SC., A.R.C.S., D.I.C., PH.D.(LONDON), F.INST.P., P.ENG.

W. H. Rapson, B.A.SC., M.A.SC., PH.D., F.R.S.C., F.C.I.C., F.T.A.P.P.I., P.ENG.

S. Sandler, M.A.SC., F.C.I.C., P.ENG.

I. H. Spinner, B.A.SC., M.A.SC., PH.D., F.C.I.C., P.ENG.

O. Trass, B.S.E.(PRINC.), SC.D.(M.I.T.), F.C.I.C., P.ENG.

M. Wayman, M.A., PH.D., F.C.I.C., P.ENG.

H. L. Williams, B.A., M.SC.(WESTERN), PH.D.(McGILL), F.C.I.C., F.R.I.C., F.P.R.I.,
C.CHEM. P.ENG.

R. T. Woodhams, B.SC., M.SC.(U.W.O.), PH.D.(BROOKLYN P.), S.P.E.

Associate Professors:

D. Barham, B.SC.ENG., D.I.C., A.R.S.M., PH.D.(LOND.)

C. E. Chaffey, B.SC., PH.D.(McGILL), P.ENG.

J. S. Hewitt, B.SC.(QU.), M.SC., PH.D.(BIRM.), P.ENG.

D. Mackay, A.R.C.S.T., PH.D.(GLAS.), F.C.I.C., P.ENG.

C. R. Phillips, B.E., PH.D.(ADELAIDE), P.ENG.

P. Y. Wang, B.SC., PH.D.(McGILL)

*For further information about the Aerospace Option, see Section IV.

Assistant Professors:

D. G. B. Boocock, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)
D. E. Cormack, B.A.SC., M.A.SC., PH.D.(CALIF.)
F. R. Foulkes, M.A.SC., PH.D., P.ENG.
Z. May, DIPL.ING.CHEM.(WARSAW), P.ENG.
M. J. Phillips, B.A.SC., M.A., (BRYN MAWR), PH.D.(J.H.U.)
M. V. Sefton, B.A.SC., SC.D.(M.I.T.), P.ENG.

Adjunct Professors:

J. H. Aitken, B.SC.(EDIN.), PH.D.
H. D. Bett, B.A., M.A., PH.D., F.C.I.C.
R. F. Hunter, B.A.SC., M.A.SC., PH.D., P.ENG.
A. J. Szonyi, DIPL.ENG.(BUDAPEST), M.A.SC., PH.D., M.B.A., P.ENG.

Lecturers:

C. C. Barnes, B.SC.(QU.)
R. B. Thompson, B.A.SC., P.ENG.

Lecturer part-time:

A. M. Rozeiu, DIP.CHEM.ENG.(BUCH.), P.ENG.

UNDERGRADUATE PROGRAM IN CHEMICAL ENGINEERING (Program 6)

Undergraduate study in the Department of Chemical Engineering and Applied Chemistry is an excellent preparation for not only a career as a professional chemical engineer, but also for many careers in applied science. In recent years, many graduates from the Department have pursued such careers in addition to those entering the major chemical and petroleum industries.

The chemical engineer is concerned with the development and operation of processes by means of which matter is chemically altered to a more useful form, and in the design, construction, operation and management of plant in which to effect such changes. In addition to such obviously chemical processes as those encountered in the petroleum refining and petro-chemical industry, a great variety of industrial processes involve chemistry and require the abilities of the chemical engineer.

In order to equip a student to start his professional career as a chemical engineer, the undergraduate course is intended to provide him with training in the principles of the major divisions of chemistry and chemical engineering, together with the essentials of other engineering subjects. An important part of the course is the application of these principles to areas of major engineering interest.

Undergraduate study in the Department of Chemical Engineering and Applied Chemistry is also an excellent preparation for work in fields other than professional engineering. In recent years, many graduates from the Department have pursued careers in law, medicine, business and teaching.

Elective subjects available in the Department allow a particular emphasis to be achieved, for example, in one or more of the following areas: environmental chemistry and engineering, polymer science, wood chemistry, materials science, ceramics, medical engineering, energy production and conservation, analytical chemistry, fluid mechanics, nuclear power engineering, nuclear chemistry, biochemical engineering, optimal control, surface chemistry, combustion, pipeline transportation, separation processes and heat transfer. Specialist courses in other Departments or Faculties may also be selected, e.g. courses in biochemistry and microbiology for a program with a bio-chemical engineering emphasis. In this way, advantage may be taken of the resources within the University, and an individual student may arrange his program to suit his desires and career objectives.

In the final year, the topic chosen for the thesis allows the student additional specialization. The thesis serves as an introduction to research and the application of principles to topics of engineering interest, and its nature may vary widely depending on the interest of the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

GRADUATE PROGRAMS IN CHEMICAL ENGINEERING

The Department of Chemical Engineering and Applied Chemistry, which also includes nuclear engineering, provides opportunities for students who would like to consider advanced studies beyond the undergraduate level toward the M.A.S.C., M.Eng. or Ph.D. degrees. Over 50 graduate level courses are offered by the Department toward the study requirement of the degree programs.

A wide range of thesis research is available in Applied Chemistry, Chemical Engineering and Nuclear Engineering processes, reflecting the broad spectrum of interests of the academic staff. This includes work in polymers; ceramic and composite materials; environmental and energy-conversion studies; chemical and nuclear reactors; separation processes; kinetics, equilibrium, fluid mechanics, heat and mass transfer in chemical systems; biochemical and biomedical engineering; electrochemistry; nuclear and radiochemistry; pulp and paper technology; pipeline transportation; process control; mathematical modelling of chemical processes; catalysis; and nuclear instrumentation.

The laboratories and facilities for graduate student research are mostly contained in the Wallberg Building which houses the undergraduate laboratories and lecture rooms as well. A broad range of modern facilities and equipment are available for experimental research.

Financial support is provided to graduate students through research grants and/or fellowships, together with some undergraduate teaching in the laboratories.

Undergraduate students interested in postgraduate programs are invited to discuss research activities and graduate studies in the Department with any member of staff at any stage of their undergraduate program. Further information may also be obtained from the Graduate Secretary of the Department in Room 240, Wallberg Building and from the Graduate School calendar.

DEPARTMENT OF ELECTRICAL ENGINEERING

Professor and Chairman of the Department:

K. C. Smith, M.A.SC., PH.D., P.ENG.

Professor and Associate Chairman of the Department:

I. McCausland, B.SC.(QU.BELFAST), M.SC.(QU.BELFAST), PH.D., P.ENG.

Professors:

K. G. Balmain, B.A.SC., M.S.(ILL.), PH.D., P.ENG.

P. P. Biringer, DIPL.ING.(BUD.), M.SC.(STOCKHOLM), PH.D., F.I.E.E.E., P.ENG.

P. E. Burke, B.E.(N.S.TECH.), M.A.SC., P.ENG.

R. S. C. Cobbold, B.SC.(LOND.), M.SC.(SASK.), PH.D.(SASK.)

E. J. Davison, A.R.C.T., B.A.SC., M.A., PH.D.(CAMB.), P.ENG.

J. M. Ham, B.A.SC., S.M.(M.I.T.), SC.D.(M.I.T.), F.I.E.E.E., P.ENG., D.A.SC.(MONTREAL),
D.SC.(QUEEN'S)

K. Iizuka, B.S.(KYOTO), M.E.(KYOTO), M.S.(HARV.), PH.D.(HARV.)

W. Janischewskyj, M.A.SC., P.ENG.

E. S. Lee, B.ENG.(McG.), M.ENG.(McG.), PH.D., P.ENG.

N. F. Moody, B.SC.(SASK.), F.R.S.C., F.I.E.E., P.ENG.

E. E. Newhall, B.SC.(ALTA.), M.SC., PH.D.

J. G. Simmons, B.SC.(LOND.), M.SC.(TEMPLE), D.SC.(LOND.), PH.D.(LOND.), F.INST.P.,
F.I.E.E., F.I.E.R.E.

A. Semlyen, D.ENG.(RUM.), PH.D.(RUM.), P.ENG.

G. Sinclair, B.SC.(ALTA.), M.SC.(ALTA.), PH.D.(OHIO STATE), F.R.S.C., F.E.I.C., P.ENG.

G. R. Slemon, M.A.SC., D.I.C., PH.D.(LOND.), D.SC.(LOND.), F.I.E.E.E., F.I.E.E., P.ENG.

H. W. Smith, B.A.SC., SC.D.(M.I.T.), P.ENG.

J. L. Yen, B.SC.(CHIAO TUNG), M.A.SC., F.R.S.C., PH.D.

W. M. Wonham, B.ENG.(McG.), PH.D.(CAMB.)

Associate Professors:

R. M. Baecker, B.SC., M.S., PH.D.

M. G. Bassett, B.A.SC., F.I.E.S., P.ENG.

P. I. P. Boulton, B.A.SC., M.A.SC., PH.D., P.ENG.

I. R. Dalton, B.A.SC., M.S.(NORTHWEST.), P.ENG.

S. B. Dewan, B.SC.(PUNJAB), M.E.(ROORKEE), M.A.SC., PH.D., I.E.E.E., P.ENG.

S. Dmitrevsky, B.A.SC., PH.D.(HARV.)

V. C. Hamacher, B.A.SC.(WATERLOO), M.SC.(QUEEN'S), PH.D.(SYR.), P.ENG.

J. J. Horning, B.A.(P.U.C.), M.S.(CALIF.), PH.D.(STAN.)

A. J. Kravetz, B.SC.(ALTA.), M.A.SC., P.ENG.

H. Kunov, M.SC.(DENMARK), LIC.TECHN.(DENMARK), P.ENG.

E. Llewellyn Thomas, B.SC.(LOND.), M.D., C.M.(McG.), F.I.E.E., F.R.S.A., F.R.S.C.,
P.ENG.

H. O'Beirne, M.A.(CAMB.), M.A.SC., P.ENG.

V. M. Ristic, DIP.ENG.(BELGRADE), M.SC.(BELGRADE), M.SC.(STAN.), PH.D.(STAN.), P.ENG.
 S. D. T. Robertson, B.SC.(QUEEN'S), D.I.C., M.A.SC., PH.D., P.ENG.
 C. A. T. Salama, M.A.SC.(U.B.C.), PH.D.(U.B.C.), P.ENG.
 A. S. Sedra, B.SC.(CAIRO), M.A.SC., PH.D., P.ENG.
 K. C. Sevcik, B.S., S.M., PH.D.
 A. Straughen, B.SC.(LOND.), M.A.SC., P.ENG.
 D. Tschritzis, B.E.(ATHENS), M.SC.(PRINC.), PH.D.(PRINC.)
 A. N. Venetsanopoulos, B.E.(ATHENS), M.A.SC.(YALE), PH.D.M.(YALE), PH.D.(YALE), P.ENG.
 Z. G. Vranesic, B.A.SC., M.A.SC., PH.D., P.ENG.
 S. Zukotynski, M.A.SC.(WARSAW), PH.D.(WARSAW), P.ENG.

Assistant Professors:

M. A. Albisser, B.ENG.(MCG.), M.A.SC., PH.D.
 B. A. Black, B.S.(COLUMBIA), S.M.(M.I.T.), PH.D.(CALIF.), P.ENG.
 M. G. Joy, M.A.SC., PH.D.
 B. C. Moore, B.S., M.S., PH.D.
 S. Pasupathy, B.E.(MADRAS), PH.D.(YALE)
 D. B. Wortman, PH.D.(STAN.), M.A.SC.(STAN.), B.A.(YALE)
 S. G. Zaky, B.SC.(CAIRO), M.A.SC., PH.D.

Visiting Assistant Professors:

P. E. Caines, B.A.(OXFORD), D.I.C., PH.D.(IMP.)
 A. J. Cousin, B.S., M.A.SC., PH.D.
 F. E. Holmes, B.A.SC., M.A.SC., PH.D.
 A. J. Laub, B.SC., M.S., PH.D.
 J. D. Lavers, M.A.SC., PH.D.
 R. Rutman, M.SC., PH.D., D.SC.

Adjunct Professors:

G. R. Lang, B.SC.(U.W.O.)
 I. H. Rowe, M.A.SC., D.I.C.(IMP.COLL.), PH.D.(LOND.), P.ENG.

Special Lecturers:

J. Endrenyi, DIPL.E.E.(BUD.), M.A.SC.(WATERLOO), PH.D.
 R. G. de Buda, PH.D., P.ENG.
 R. S. Segsworth, B.A.SC.

UNDERGRADUATE PROGRAM IN ELECTRICAL ENGINEERING (Program 7)

Electrical Engineers are concerned with all forms of electrical phenomena and applications. The early applications of electricity – the generation, transmission and utilization of

electrical energy and the communication of information – are still important, but have been or are likely to be transformed by new applications and potential applications such as magneto-hydrodynamic generation, transmission by superconductors, and satellite communication. In addition, there are completely new fields of application which were not even envisaged a few years ago. There is a growing demand for complex electrical measuring and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas, the Electrical Engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of bio-medical engineering, or he may have to coordinate the application of many technologies in a single project.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation of engineering science and design technique. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will be relevant for several years. In addition, the undergraduate is given the opportunity of studying non-technical subjects of his own choice.

The electrical engineer makes extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and specialization in the final year. In the final year, students freely select their whole program from a wide range of elective subjects. The under-graduate course is intended to provide a base on which to build the continuing education that is needed throughout the Engineer's career.

Electrical Engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. For further information on post-graduate studies, refer to the following paragraphs and to the calendar of the School of Graduate Studies.

GRADUATE PROGRAMS IN ELECTRICAL ENGINEERING

The Department offers graduate study and research opportunities in a wide range of fields within the Electrical Engineering discipline. The staff, comprising specialists in Biomedical Engineering, Communications, Computers, Control Systems, Power Devices and Systems, Solid State and Electronics, and Wave Sciences, conducts an active research program, including both applied and basic topics. Excellent experimental and computing

facilities are available. An interdepartmental program in association with the Department of Astronomy is offered in Radio Astronomy.

Programs available lead to the M.ENG., M.A.SC., and PH.D. degrees. A part-time evening program is available for the M.ENG.

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

Professor and Chairman of the Department:

J. M. Toguri, M.A.SC., PH.D., P.ENG.

Professors:

C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND), F.R.I.C., F.I.M.M.

K. T. Aust, M.A.SC., PH.D., P.ENG.

G. B. Craig, M.A.SC., PH.D., P.ENG.

S. N. Flengas, B.SC.(ATHENS), D.I.C., PH.D., D.SC.(LOND.), F.C.I.C.

Mrs. U. Martius Franklin, PH.D.(BERLIN)

H. U. Ross, C.D., B.ENG., M.SC., (McG.), F.I.M.M., P.ENG.

J. W. Rutter, M.A., PH.D., P.ENG.

Associate Professors:

R. T. McAndrew, B.SC.(QU.), PH.D.(U.B.C.), P.ENG.

A. McLean, B.SC., PH.D.(GLAS.), P.ENG.

W. A. Miller, B.ENG., M.ENG., PH.D.(McG.), P.ENG.

B. Ramaswami, B.SC., D.I.I.SC., M.A., PH.D.(HARVARD)

G. C. Weatherly, B.A., PH.D.(CANTAB), P.ENG.

Special Lecturer:

R. S. Segsworth, B.A.SC., P.ENG.

UNDERGRADUATE PROGRAM IN METALLURGY AND MATERIALS SCIENCE (Program 8)

In terms of its diversity and scale of operation, the metallurgical industry in Canada ranks among the world's outstanding industrial achievements; it is also responsible for a considerable portion of the country's economy. In this field of endeavour, the metallurgist fulfils an important and useful role in the extraction, fabrication and application of metals and their alloys.

In recent years the needs of modern society have made increasingly severe demands upon materials required for various types of construction. This has led to the development of the new field of materials science which applies many of the techniques of the metallurgist and others to the study of a wide spectrum of materials. For example the practical application of nuclear energy is limited only by the availability and costs of

materials which can withstand in-pile operation; advances in communications depend upon the development of materials having special electrical and magnetic properties; aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure.

The program is perhaps unique in the Faculty in that it draws heavily on both physics and chemistry. It should, therefore, appeal to students with an interest in either of these basic scientific fields. The program is designed to place primary emphasis upon the fundamental principles of metallurgy, materials science and engineering rather than on the operative conditions of industrial practice. In the Fourth Year, each student prepares a thesis on an experimental problem which, where possible, is related to research in progress within the Department. A wide range of electives in the Fourth Year culminates in a final Term 4S which consists entirely of material chosen by the student in consultation with an assigned staff tutor. In this manner, the student may elect courses which emphasize either the industrial or the research aspects of metallurgy, materials science and engineering.

The Department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes mass spectrometers, x-ray diffraction units, an electron beam microprobe analyzer, electron microscopes, several optical metallographs, and materials preparation and testing equipment. Facilities for mineral processing and for the production and measurement of high temperatures and high vacuum are also available.

GRADUATE PROGRAMS IN METALLURGY AND MATERIAL SCIENCE

The graduate Department offers Master of Engineering, Master of Applied Science and Doctor of Philosophy degrees in physical metallurgy, materials science, and extractive metallurgy. Detailed information on admission is available from the graduate secretary.

The research equipment includes modern facilities for optical, electron and X-ray metallography, mechanical testing, particle characterization, the production of high temperatures and controlled atmospheres, calorimetric and other thermodynamic measurements at high temperatures, crystal growth, etc. The Department has a well equipped central machine shop with auxiliary graduate and undergraduate machining and glass blowing facilities.

Research interests in the Department include process development, physical chemistry of metal extraction, mineral processing, hydrometallurgy, powder metallurgy, solidification and crystal growth, structure and mechanical properties of metallic, ceramic and composite materials and historical studies of ancient materials such as Chinese bronzes.

Information is given in Section III about the *departments* and *divisions* of the Faculty, about their staffs and the related undergraduate and graduate programs.*

There are other structural elements of the University, *centres* and *institutes*, that play an important part in the work of education and research in this Faculty. These vary widely in their structure and objectives. They range from having major space and facilities to very little; from being purely undergraduate in function to purely graduate; from being imbedded within a department of this Faculty to major inter-Faculty interdisciplinary entities; from being financed like departments of the Faculty to having very different budgetary arrangements.

Each is described briefly in the following pages. Since, unlike all the others, the academic staff of the Institute for Aerospace Studies have no other appointments, a list of them is included.

INSTITUTE FOR AEROSPACE STUDIES

The University of Toronto has played an important role in the aerospace field since the beginning of manned powered flight. Two of its engineering graduates F. W. Baldwin and J. A. D. McCurdy made the first flight by a Canadian and the first flight in Canada respectively, in 1908 and 1909, in aircraft which they helped to engineer and build. These historical events were achieved only a few years after the famous first flight by the Wright brothers in 1903. For nearly three decades, the University of Toronto has been the only Canadian university to offer a broad and coherent program of studies in the aerospace sciences and engineering at the Bachelor's, Master's and Doctorate levels. This program is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft, and air-cushion vehicles, and for fundamental research in many of the relevant underlying areas of science. Future Canadian needs for air and surface transportation, earth-satellite applications, fusion, noise and pollution sensing and control and laser technology are significant

*Additional information about graduate programs may be found in the Calendar of the School of Graduate Studies.

factors in determining the content of the courses and the design and research projects undertaken.

The courses of study available comprise a basic four-year program leading to the B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and a subsequent Doctoral program. The undergraduate (Bachelor's) program consists of four years in Engineering Science (Aerospace Option 5a), and the post-graduate programs are taken in the Department of Aerospace Science and Engineering of the School of Graduate Studies. The staff at the Institute for Aerospace Studies provides the instruction at the undergraduate and graduate levels in all aerospace-related subjects.

UNDERGRADUATE PROGRAM IN AEROSPACE SCIENCE AND ENGINEERING

The details of the undergraduate program are given in this Calendar (Section XI) and are seen to consist mainly of intensive studies in the fundamentals of mathematics, physics, and engineering sciences correlated with design, analysis and synthesis activities illustrative of modern engineering practice in the aerospace field. In the final two years, the program is oriented to the special needs of the aerospace field, and includes some specialized courses. Graduates of this program are able to fill a variety of positions in education, industry and government, but the fifth year (see below) is recommended for those who wish to improve their qualifications for employment as aerospace engineers.

The modern aerospace field has diversified into a wide variety of technological areas and in addition to courses in the traditional aerospace areas (aerodynamics, stability and control of aircraft, gasdynamics, mechanics of structures, aeroelasticity, aeroacoustic theory and noise control, engineering design), an opportunity is also provided to study several courses at the applied-physics/aerospace interface (quantum and statistical mechanics, lasers, plasmas, and energy). Students are encouraged to consult a member of the Institute staff in making elective course selections.

GRADUATE PROGRAM IN AEROSPACE SCIENCE AND ENGINEERING

If the student's academic record in the undergraduate program meets the requirements for admission to the School of Graduate Studies, he may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng. degree in the (graduate) Department of Aerospace Science and Engineering. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduate Studies. The facilities of the Institute for Aerospace Studies are available to the student for research or project work. For details of research fields, assistantships, scholarships and demonstratorships, students should consult the Secretary of the graduate department.

It should be noted that a student who has graduated in another branch of Engineering, or in science or mathematics, and who desires to qualify as an Aerospace Engineer may be admitted to the graduate program. In that case the courses leading to the M.A.Sc. or

M.Eng. degree will be arranged on an individual basis so that any deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and research leading to the Ph.D. degree.

STAFF OF THE INSTITUTE FOR AEROSPACE STUDIES

Professor and Director of the Institute:

J. H. de Leeuw, DIPL.ENG.(DELFT), M.S. in A.E.(GEORGIA TECH.), PH.D., F.C.A.S.I., F.A.P.S.

Professor and Associate Director:

J. B. French, B.A.SC.; M.SC.(BIRMINGHAM), PH.D., F.R.S.A.

Professors:

B. Etkin, B.A.SC., M.A.SC.; D.ENG.(CARLETON), F.R.S.C., F.C.A.S.I., F.A.I.A.A.

I. I. Glass, B.A.SC., M.A.SC., PH.D., F.A.P.S., F.A.A.A.S., F.C.A.S.I., F.A.I.A.A., F.R.S.C.

P. C. Hughes, B.A.SC., M.A.SC., PH.D., F.C.A.S.I.

H. S. Ribner, B.S.(CAL. TECH.), M.S., PH.D.(WASH.), F.A.P.S., F.A.S.A., F.C.A.S.I., F.A.I.A.A.

R. C. Tennyson, B.A.SC., M.A.SC., PH.D.

Associate Professors:

J. D. DeLaurier, B.S.(ILL.), M.S., PH.D.(STAN.)

G. W. Johnston, B.A.SC., M.A.SC., PH.D., F.C.A.S.I.

R. M. Measures, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)

L. D. Reid, B.A.SC., M.A.SC., PH.D.

P. A. Sullivan, B.E., M.E.(N.S.W.), D.I.C., PH.D.(LOND.)

Assistant Professors:

J. A. Hansen, B.A.SC., M.A.SC., PH.D.(WATERLOO)

J. W. Locke, B.A.SC., M.A.SC., PH.D.

P. C. Stangeby, B.SC., M.SC.; DIPL. PLASMA SCI., D.PHIL.(OXON)

Lecturer:

A. A. Haasz, B.A.SC., M.A.SC., PH.D.

INSTITUTE OF BIOMEDICAL ENGINEERING

Director: R. S. C. Cobbold

Biomedical Engineering is the application of the concepts and methods of engineering to the study of living organic systems, and to the development of instruments and techniques

for biological and medical practice. The ten-member faculty of the Institute is composed of both engineers and medical scientists. Augmenting this faculty are some 40 associates of the Institute, many of whom act as supervisors of students at the Institute. All full-time students at the Institute are graduate students at the University, registered in one of the Graduate Departments and proceeding towards an M.A.Sc., M.Sc., M.Eng., or Ph.D. degree.

The Institute's laboratories are located in the Rosebrugh Building and the Medical Sciences Building on the St. George campus. These laboratories are designed for the construction and testing of electrical and mechanical experimental equipment; real time, interactive computer applications; small animal surgery; and chemical bioengineering. Since many members of the Institute hold appointments in the several nearby teaching hospitals and medical research centres, much of our research is carried out in these hospitals and centres using facilities which they provide.

The Faculty of the Institute participates in undergraduate teaching through various engineering and medical departments, and, in addition, presents one elective course, ELE 445S, in Biomedical Engineering. At the graduate level, some 14 courses are offered through the Institute. An undergraduate student who is interested in Biomedical Engineering should consider taking ELE 445S and perhaps doing his undergraduate thesis in this area. Many interesting topics are offered by the Faculty each year.

COCKBURN CENTRE FOR ENGINEERING DESIGN

Director: I. W. Smith, Cockburn Professor

This Centre was established by Council in 1972, from the earlier Cockburn Unit in Engineering Design that was formed in 1969 to improve and develop design teaching in the Faculty. It is administered by the Cockburn Professor and an executive group comprising six Cockburn Associates appointed from the staffs of the Departments of Chemical, Civil, Electrical, Industrial, and Mechanical Engineering and the Institute for Aerospace Studies. Additionally there are other members of the teaching staff directly concerned with courses developed and given by the Centre, and representatives from industry, the Ontario Government Ministry for Industry and Tourism, and the Association of Professional Engineers of Ontario.

The efforts of the Cockburn Centre are concentrated on undergraduate design education to broaden the capabilities for design management at the baccalaureate level and to provide a base for graduate studies beyond the usual analytic/research format. The overall design process, from problem recognition through synthesis and analysis of alternate solutions, testing of a prototype, selection and presentation of an acceptable answer, is being emphasized, beginning with a First Year course CED101S. Problems are gathered from industry and the community, with as much extramural involvement by the students as possible. Design groups of from two to ten students, preferably combining the skills and interests of more than one engineering discipline, are encouraged to develop a team capability for dealing with complex engineering systems. These students learn about

effective group dynamics, the management of the entire design process, the problems of scheduling construction and testing, and the presentation of completed projects.

The Fourth Year course CED401, which by arrangement with some Departments can take the place of the two-term thesis requirement, provides a unique opportunity for senior students to apply their expertise within an engineering team effort.

COMPUTER SYSTEMS RESEARCH GROUP

Chairman: K. C. Sevcik

The Computer Systems Research Group was established in 1968 under the joint administration of the Departments of Computer Science (Faculty of Arts and Science) and Electrical Engineering of the University of Toronto. The major objectives of the Group are to do research and development on the design and operating characteristics of complex computer systems, and to see that the results of these investigations are used to improve information processing in Canadian business and government, as well as in the Universities.

Specific objectives of CSRG include:

- The development of specialized problem-oriented languages and techniques for their efficient implementation, including compiler-compiler systems.
- Research into the problems of producing reliable and efficient computer software, and the development of tools to assist in this process.
- Human-factors engineering of computer systems, both those intended for use by experts, and those designed to be used by people without computer training.
- The development of advanced techniques for graphical communication with computer systems, including systems for computer-produced animated motion pictures.
- Hardware design and the production of specialized devices.
- Liaison with the community.

CSRG membership includes about 25 faculty members with academic appointments in the Departments of Computer Science, Electrical Engineering, and Industrial Engineering, as well as the Faculty of Management Science, and about 40 graduate students.

INSTITUTE FOR ENVIRONMENTAL STUDIES

Director: F. K. Hare

This Institute coordinates interdisciplinary studies of environmental problems in the University. It has close working relationships with the Faculty of Applied Science and Engineering, and with several other Faculties, but is itself part of the School of Graduate Studies. It also has close links with the federal and provincial governments, and with

international agencies. It is able to help in the work of graduate students in Engineering departments, some of whom are housed in the Haultain Building, I.E.S. headquarters.

The work of I.E.S. is undertaken by study groups and working groups, each of which takes some broad environmental problem as its focus of study. Currently active groups include those working on oil and gas, persistent substances, water resources management, water quality, solid waste management, air pollution, and climatic change and human response. Other groups are active in such areas as nuclear technology and environmental impact appraisal. Several of these groups have substantial research funds, and graduate students are involved in the work of most of them. Specialized laboratories are available to support the work, and extensive field programs are mounted. There is also a Great Lakes field station at Baie du Dore, on Lake Huron immediately north of the Douglas Point-Bruce nuclear generating station.

Students from Applied Science and Engineering may well find I.E.S. a convenient way of establishing useful contact with researchers and students from other areas, such as Medicine, Social Sciences and Law. The Institute offers several cross-disciplinary graduate courses, and has a limited number of graduate scholarships available for students working on environmental problems.

CENTRE FOR THE STUDY OF MATERIALS

Chairman: G. B. Craig

The Centre was established in 1970 (under the name Materials Research Centre) as an interdisciplinary research body, in order to further and help coordinate teaching and research in materials in all divisions of the University.

Materials research consists of a blending of science and engineering in a study of the structures, properties and applications of all classes of materials. By its nature the work of the Centre is interdisciplinary, involving collaboration with many graduate departments of the University, and staff in a number of Faculties.

Graduate students wishing to work in the general field of materials should register in the appropriate graduate department of their major discipline under the general regulations of the School of Graduate Studies. In consultation with staff of the Centre and the appropriate department, the Centre will arrange, for individual students, interdisciplinary programs involving more than one department but leading to a degree in one of them.

A brochure describing the facilities of the Centre and graduate work in materials is available from the School of Continuing Studies, or the Chairman of the Centre.

SYSTEMS BUILDING CENTRE

Chairman: M. W. Huggins

The Systems Building Centre was established as an interdisciplinary unit within the Faculty with the objective of improving the building process. Its prime function has been

to propose and assist in instruction of undergraduate and graduate courses related to building science and modular construction. Its staff have also directed the work of graduate students enrolled in departments of the School of Graduate Studies, who wish to do research related to improving the building process.

On its staff are research assistants and technicians who devote full time to research projects carried out by the Centre on behalf of and in cooperation with industry and government.

PROFESSORES EMERITI

E. A. Allcut, M.SC.(BIRM.), M.E., F.R.A.E.S.,
Professor Emeritus of Mechanical Engineering

J. G. Breckenridge, B.A.SC., PH.D.(CAMB.),
Professor Emeritus of Chemical Engineering and Applied Chemistry

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

C. Hershfield, B.SC.C.E.(MAN.), M.A.SC., F.E.I.C.
Professor Emeritus of Civil Engineering

P. B. Hughes, B.SC.(McG.), D.ENG.(EMBRY RIDDLE),
Professor Emeritus of Mechanical Engineering

L. E. Jones, B.SC.(C.E.),(MAN.), M.A.SC., PH.D., F.I.MECH.E., F.E.I.C., P.ENG.
Professor Emeritus of Mechanical Engineering

G. K. Korbacher, DIPL.ING.(BERLIN), PH.D.(BRAUNSCHWEIG),
Professor Emeritus of Aerospace Studies

G. R. Lord, B.A.SC., S.M.(M.I.T.), PH.D.,
Professor Emeritus of Mechanical Engineering

O. J. Marshall, B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W. G. McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

C. F. Morrison, B.E.(SASK.), M.S.C.(McG.),
Professor Emeritus of Civil Engineering

G. N. Patterson, B.SC.(ALTA.), M.A., PH.S., LL.D., D.SC., F.R.S.C., F.R.A.E.S., F.C.A.S.I.,
F.A.I.A.A., F.A.A.A.S.,

Professor Emeritus of Aerospace Studies

L. M. Pidgeon, M.B.E., B.SC.(OXON), PH.D.(McG.), F.R.S.C.,

Professor Emeritus of Metallurgy and Materials Science

A. Porter, M.SC.(MANCH.), PH.D.(MANCH.), F.R.S.C.

Professor Emeritus of Industrial Engineering

H. R. Rice, B.SC.(QUEEN'S),

Professor Emeritus of Mining Engineering

R. S. Segsworth, B.A.SC.

Professor Emeritus of Electrical Engineering

E. A. Smith, M.A.(McM.),

Professor Emeritus of Chemical Engineering

G. F. Tracy, B.A.SC., S.M.(M.I.T.),

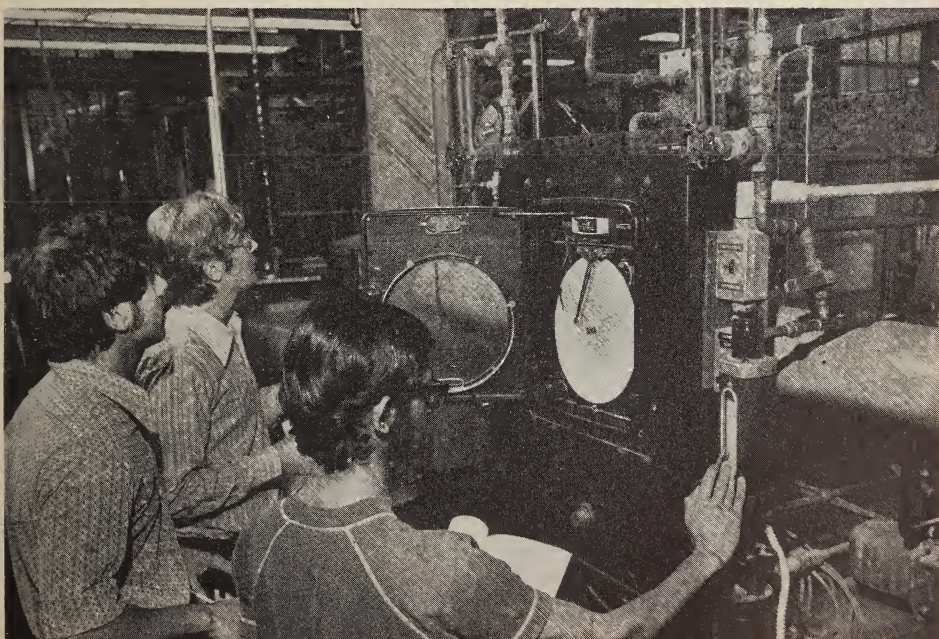
Professor Emeritus of Electrical Engineering

C. E. Wrenshall, B.E.(SASK.)

Professor Emeritus of Engineering Graphics

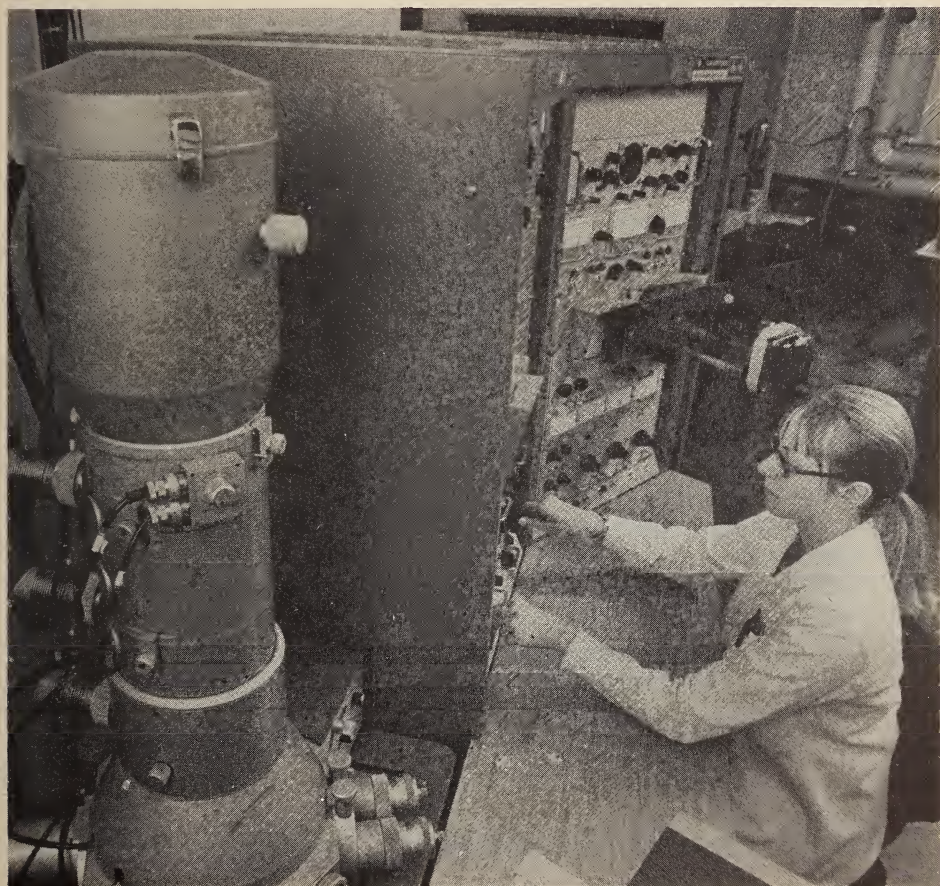
W. J. T. Wright, M.B.E., B.A.SC., B.A.,

Professor Emeritus of Engineering Drawing



<i>Chancellor</i>	Eva W. Mader Macdonald (Mrs.), MD, CM, DPH
<i>President</i>	J. R. Evans, MD, DPHIL, FRCP[C]
<i>Special Assistant to the President</i>	J. H. Sword, BA, MA, LLD
<i>Chairman of the Governing Council</i>	C. Malim Harding, OBE, BA
<i>Vice-President and Provost</i>	D. A. Chant, BA, MA, PH D, FRES, FRSC
<i>Vice-Provost</i>	J. D. Hamilton, MD, FRCP[C], DSC
<i>Vice-Provost</i>	M. Israel, BS, MA, PH D
<i>Vice-Provost</i>	P. P. M. Meincke, B SC, MA, PH D
<i>Vice-Provost</i>	R. Ross, MBE, MA
<i>Vice-President, Research and Planning</i>	G. E. Connell, BA, PH D
<i>Assistant Vice-President</i>	G. P. Hiebert, B COM, CA
<i>Vice-President, Business Affairs</i>	A. G. Rankin, B COM, FCA
<i>Vice-President, Internal Affairs</i>	F. Iacobucci, B COM, LLB, DIP INT LAW
<i>University Ombudsman</i>	E. A. McKee, BA, MA
<i>Chief Librarian</i>	R. Blackburn, MA, BLS, MS, LLD
<i>Secretary of the Governing Council</i>	D. S. Claringbold
<i>Director of Admissions</i>	W. Kent, BA, MA
<i>Director of Student Awards</i>	P. S. Phillips, BA, CA
<i>Director of Student Record Services</i>	J. C. Wilson, BASC, MSC, PH D
<i>Warden of Hart House</i>	J. G. Lengellé, BA, MA, PH D
<i>Coordinator of Campus Services</i>	H. L. Reimer (Miss), BA, BPAED
<i>Director of Advisory Bureau</i>	D. J. McCulloch, BA, MD, DPSYCH, FRCP(C)
<i>Director of Athletics and Recreation (Men)</i>	A. D. White, BA, MED
<i>Director of Athletics and Physical Education (Women)</i> ...	A. Hewett (Miss), BED, (PE)

Director of Career Counselling and Placement Centre R. Frankle (MS), BA
Director of University Health Service G. E. Wodehouse, MC, MD, FRCP(C), MRCP
Director of Housing Service S. Mason (MS), BA
Acting Director of International Student Centre E. Paterson (MS), BA



Limitation of Enrolment

The Faculty of Applied Science and Engineering reserves the right to limited the number of registrants in any program or course described in this calendar in circumstances where the number of qualified applicants exceeds the teaching and other resources available to the Faculty.

Full details of the University of Toronto undergraduate admission requirements for 1977 are contained in the Undergraduate Admission Handbook 1977-78 available on request from the Office of Admissions, University of Toronto, Toronto, Ontario, Canada, M5S 1A3 and in all Ontario secondary schools. The 1976 requirements for admission to the First Year of the undergraduate programs in the Faculty of Applied Science and Engineering follow:

1. ONTARIO YEAR 5

Entrance to the First Year of the undergraduate programs is offered, depending upon the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

1. Completion of secondary school studies, including a full program of academic work at the Year 5 level.
2. A recommendation by the secondary school last attended regarding probable success in university studies.
3. A complete academic report for the last three years of secondary school.

The Year 5 program should include Relations and Functions, Algebra, Calculus, Physics and Chemistry. Superior students, who have completed six credits at the Year 5 level, but whose programs do not include all of these subjects will also be considered. When admissibility is not clear, consideration will be given to evidence of motivation and of ability with language.

In addition, candidates seeking admission to the program in Engineering Science should have excellent standing.

2. CANDIDATES OFFERING CERTIFICATES OTHER THAN ONTARIO YEAR 5:

The following certificates are usually accepted as equivalent to Ontario Year 5 although individual subjects cannot always be equated. The candidates must offer from their final secondary school year, a full Senior Matriculation program including mathematics, physics and chemistry.

Ablerta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Saskatchewan — Grade 12

Newfoundland — First Year Memorial University

Prince Edward Island — First Year University of Prince Edward Island

Quebec — C.E.G.E.P.I or equivalent

The following are also usually accepted as equivalent to Ontario Year 5 although individual subjects cannot always be equated. Candidates applying for admission to the Faculty of Applied Science and Engineering should include mathematics, physics and chemistry in their studies.

UNITED STATES, CENTRAL AND SOUTH AMERICA

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Excellent students with high school diploma and C.E.E.B. Advanced Placement Examinations will be considered.

ENGLAND, WEST INDIES, EAST AND WEST AFRICA, HONG KONG

General Certificate of Education, Higher School Certificate or University of Hong Kong Matriculation Certificate showing either passes in five subjects of which at least two must be passed at advanced (or principal) level; or passes in four subjects of which at least three must be passed at advanced (or principal) level. In either case passes are required in physics, chemistry and an acceptable mathematics subject. At least two of these must be at advanced level.

EUROPE AND COMMONWEALTH

A Graduation (Maturity) certificate from the final year of secondary school is required from most European and Commonwealth countries.

INDIA, PAKISTAN, BANGLADESH

Bachelor's degree with standing in the first division.

JAPAN, KOREA, TAIWAN

First Year University standing in acceptable subjects from an accredited institution.

Second Year University standing in acceptable subjects from an accredited institution.

3. STUDENT VISA APPLICANTS

The Faculty of Applied Science and Engineering admits a limited number of applicants to the first or higher years who come to Canada on student visas. Having regard to the fact that the Faculty cannot accept all qualified applicants for admission, and that its primary responsibility as a public institution is to those who are either Canadian citizens or landed immigrants, the number of places offered to qualified student-visa applicants will not exceed 5% of the total admitted. Of these, no more than half will be accepted from any single country unless there be insufficient qualified applicants to fill the remaining places. These numbers are upper limits, and fewer may be admitted in any given year, depending on the number and qualifications of all applicants to the Faculty. Applicants on student visas must present evidence also of an adequate command of the English language and compete on the grounds of academic merit with all other applicants.

4. STANDARDIZED TESTS

Candidates from educational jurisdictions outside Ontario may improve their competitive position by taking the aptitude and applicable achievement tests offered by the College Entrance Examination Board. For information they should write to the College Entrance Examination Board, Box 592, Princeton, New Jersey 08540, U.S.A.

5. ENGLISH FACILITY

In addition to meeting the academic requirements outlined above, non-Canadian applicants whose mother tongue is not English and who have not had their secondary school instruction in a Canadian secondary school for at least two years are required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.). The University of Toronto is a sponsoring agency for the University of Michigan English Language Test and information about the test is sent to any applicant of whom it will be required.

6. NON-MATRICULANTS (MATURE STUDENTS)

For information regarding admission as a non-matriculant (mature student), please consult the Office of Admissions.

7. APPLICATION PROCEDURES

Candidates currently in Ontario Year 5 should apply through their high school using the general application for admission of the Ontario Universities' Application Centre.

All other candidates should write to the Office of Admissions, giving details of their previous academic work. If, after evaluation, a candidate appears eligible for admission consideration, he will receive an official application.

8. FINAL DATE FOR SUBMISSION OF APPLICATIONS

The final date for the receipt of applications is May 1. Only in circumstances deemed exceptional will a late application be considered. For further information consult the current Undergraduate Admission Handbook. Please note that the deadline for submitting applications in 1977 will be April 1.

9. EARLY ADMISSION

(Ontario Year 5 students only)

Ontario Year 5 students with good school records may be offered admission as early as June 4, 1976.

Students wishing to be considered for Early Admission should ensure that their applications are forwarded by their schools to the Ontario Universities' Application Centre not later than December 31, 1975.

10. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

11. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

COLLEGE MEMBERSHIP

New College and Innis College are multi-faculty colleges established within the University of Toronto. It is possible, but not obligatory, for students of the Faculty of Applied Science and Engineering to become members of these colleges. Application for membership is at the option of the student.

Students entering the First Year who are interested in becoming members of either college should indicate their choice in the space provided on the University's admission application form. A college fee of \$19 for New College, \$32 for Innis College is required upon acceptance.

The facilities of Innis College and New College are described below.

INNIS COLLEGE

Innis College was constituted on July 1, 1964, and admitted its first students in the following September. It is a multi-faculty college of the University of Toronto, and includes undergraduate students in all Faculties and Schools of the University.

A special feature is the Writing Laboratory. This service offers assistance to Innis College students in the skills and methods of writing essays and other academic reports. A staff of experienced teachers is available to give individual instruction.

The College has limited residential space available in houses on campus. Separate application for residence accommodation must be made directly to the Residence Co-ordinator of Innis College.

Students entering First Year will be invited to apply for membership after they have been accepted into their Faculty or School. Students entering the Second to Fourth Years who wish to join the College should obtain an application form from the Registrar, Innis College, University of Toronto.

NEW COLLEGE

New College is a multi-faculty co-educational college established in 1962; in addition to students from the Faculty of Arts and Science, those from other Faculties and Schools are eligible for membership. This gives students from all divisions of the University the opportunity to participate in the activities of a college and to associate with students in other fields of study. Individual tutoring is provided for students in some subjects and the Writing Facility offers assistance in written English and French.

The new buildings centrally located on the west campus, provide academic, social and dining facilities for all members of the College and in addition accommodate nearly 300 male students and 380 women students in residence.

Students applying for membership in the College who wish accommodation in the Residence must apply on the prescribed form which may be obtained from the Dean of Men or the Dean of Women, New College.

RESIDENCE ACCOMMODATION

DEVONSHIRE HOUSE

Devonshire House, the University Residence for Men, accepts students from all Faculties. The facilities of the residence include a reading library, common rooms, music

practice room, kitchenettes, laundry room, television and games rooms. It does not have a dining hall. Members may take their meals at Hart House, New College, University College Women's Union or Howard Ferguson Hall, all located nearby.

Application forms may be obtained from the Secretary to the Dean, Devonshire House, University of Toronto, Toronto M5S 1A1. Application should be made as early as possible.

NEW COLLEGE

The residence facilities of New College, and the procedure for application, are described in the entry under Colleges, above.

OTHER COLLEGES

Each of the four Arts Colleges also maintains a residence into which some engineering students may be accepted. Further information may be obtained from the Dean of Women or the Dean of Men at University College, Victoria College, Trinity College or St. Michael's College.

HOUSING SERVICE

For students, staff and faculty who require off-campus accommodation, the University displays lists of rooms, apartments and houses in the Housing Service offices at 49 St. George Street, Toronto, Canada M5S 1A1. The places listed are for immediate occupancy, and since the volume of such listings precludes inspection by the University, accommodation cannot be guaranteed nor reserved in advance on behalf of prospective tenants.

Persons from out of town should plan to arrive in Toronto a few days prior to their university commitment, and stay in a hotel while they make permanent arrangements.

UNIVERSITY APARTMENTS

Although unfurnished apartments of this complex were designed to accommodate married students of the University of Toronto, applications from single students may be given consideration should circumstances permit. The apartments are located at 30 and 35 Charles Street, near the St. George campus. More information and applications may be obtained by writing to the University Housing Service, 49 St. George Street, Toronto, Canada, M5S 1A1.

CAMPUS CO-OPERATIVE RESIDENCE INCORPORATED offers residence and apartment accommodation for graduate and undergraduate students. Total occupancy is 300 in residence, half male, half female, and 50 in apartments. Meals are provided, and non-

residents are invited to eat at the Co-op Dining Rooms. Since the University of Toronto has no official connection with Campus Co-operative Residence, Inc., inquiries should be addressed direct to Campus Co-operative Residence Incorporated, 395 Huron Street, Toronto, Ontario M5S 2G5.

TARTU COLLEGE

Tartu College, opened in 1969, offers accommodation to undergraduate and postgraduate students in 444 single rooms and 15 double rooms. Cooking facilities are provided for groups of six. The college is located on Bloor Street at Madison Avenue. Since the University has no official connection with the college, all enquiries should be addressed to the Reservations Office, Tartu College, 310 Bloor Street West, telephone 925-4747.

STUDENT SERVICES AND FACILITIES

UNIVERSITY HEALTH SERVICE

The University Health Service operates a medical clinic at 256 Huron Street, a psychiatric consultation service at 2 Bancroft Avenue, an infirmary service at 42 St. George Street and an athletic injury surgery in Hart House.

All students are urged to obtain medical and hospital insurance coverage through the Ontario Health Insurance Plan (OHIP).

THE UNIVERSITY OF TORONTO CAREER COUNSELLING AND PLACEMENT CENTRE

The Centre, located at 344 Bloor St. West, Fourth Floor is open from 8:45 am to 5:00 pm each week day, and one evening per week the Career Library remains open until 8 pm. Counselling Staff are available to discuss with Engineering undergraduates and graduates possible career alternatives, employment opportunities, and market conditions.

Students seeking summer employment should visit the Centre in early October if they wish to participate in the Summer On-Campus Recruitment Program since a considerable number of large companies seek engineering students for positions during the course of this program which runs from November 1 to March 31. In addition, more general kinds of summer employment are posted daily on our bulletin boards, especially during the peak period of March to June.

Students who are in their graduating year should check with the Centre in late September for information regarding the Permanent On-Campus Recruitment Program which begins November 1 and ends March 31. Because of the large number of companies which prescreen candidates, it is necessary to hand in applications six weeks before a company's interview date(s). We also have a Permanent Job Registry for those who are seeking permanent employment at any point in their academic studies as well as upon graduation. For this service, one must register to receive mailings of current job listings.

HART HOUSE

Hart House, a gift of the Massey Foundation, serves as a centre for the University community.

All full-time University of Toronto students and part-time students who pay Hart House fees are members of Hart House. Membership covers a wide variety of activities including concerts, debates, poetry readings and art exhibitions. Students are welcome to use the many clubs and common rooms and squash courts as well as the Farm in the Caledon Hills. The House is open from 7:00 a.m. to midnight every day of the year.

Food services are available from 8:00 a.m. to 11:30 p.m.: full-course meals in the Great Hall, table-service in the fully-licensed Gallery Dining Room, a coffee-shop and Pub in the Arbor Room and Tuck Shop. For further information about Hart House phone 978-5361.

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:

Scholarships and bursaries available to students entering the First Year are listed on page 50. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close in April.

Non-Ontario Students:

All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 50 to 53. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

GENERAL TERMS AND CONDITIONS

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the Spring Term, the candidates being ranked on the basis of their achievement in the Spring Term and the Fall Term previously completed.

To be eligible for any scholarship or award granted solely on academic standing a student must have completed not less than the normal full load within the two terms upon which the award is based. A student whose program in these two terms contains repeated courses will only be eligible if his aggregate of new courses is equal to or greater than 96 units.

Unless otherwise specified in the terms of award, scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted. If the award is based on a single course or on a part of the work of the term, the candidate must obtain unconditional pass standing in the work of the term, but need not obtain honours on the work of the term unless the terms of the award so specify.

A candidate will not be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the Calendar specifies otherwise. Only one of those awards marked with an asterisk may be held in any one year.

Tuition and residence fees are a first charge against awards. After the deduction of the applicable charges, any balance remaining will be paid to the recipient on November 20. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

The Governing Council may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR

(† indicates that application is required)

Alumni Association War Memorial Scholarships	†	\$ 500	page 78
J. P. Bickell Foundation Scholarships	†	\$ 500	57
J. W. Billes Admission Scholarships	†		58
Children of War Dead Education Assistance	†		60
Engineering Alumni Centennial Admission Scholarships (7)	†	\$1000	62
Grabill Admission Scholarship	†	\$ 500	64
Hagarty Memorial Scholarship	†	\$ 60	64
The Murray Calder Hendry Scholarship	†	\$ 500	65
Roy Jarvis Henry Admission Scholarships (3)	†	\$ 500	66
J. Edgar McAllister Foundation Admission Awards (25)	†	\$1000	67
Lachlan Dales McKellar Admission Scholarships (2)	†	\$ 500	69
George R. Mickle Admission Bursaries	†	\$1000	70
O.H.A. War Memorial Scholarship	†	\$ 200	71
Ontario Student Assistance Program	†		71
A.P.E.O. Admission Scholarship	†	\$ 500	72
Regular Officer Training Plan	†		74
Helen E. Rogers Admission Scholarships	†		75
Simpsons-Sears Limited (Northern Ontario) Scholarship	†	\$ 100	76
Walter Sterling Admission Scholarships	†		77
Wallberg Admission Scholarships (6)	†	\$1000	79

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR

(† indicates that application is required)

Baptie Scholarship		\$ 175	56
Canadian Bechtel Limited Bursaries	†		57
J. P. Bickell Foundation Scholarships			57
T. H. Bickle Prize		\$ 30	58
Crocker Foundation Bursaries	†		61
John M. Empey Scholarship		\$ 170	62
Engineering Society Centennial Award		\$ 100	62
The George A. Guess Scholarships			65
I.B.M. Canada Bursary Plan	†		66
Johnson's Wax Scholarship		\$ 800	66
*J. Edgar McAllister Foundation Undergraduate Awards		\$1000	67
Garnet W. McKee-Lachland Gilchrist Scholarship in			
Engineering Science		\$ 110	68
MacLennan - MacLeod Memorial Prize		\$ 25	69
Ontario Chapter American Society for Metals Bursaries	†		55
Ontario Student Assistance Program	†		71

Paulin Memorial Scholarship		\$ 600	72
Procter and Gamble Bursary	†		72
*Professional Engineers Scholarship		\$ 250	72
Ransom Scholarship in Chemical Engineering		\$ 325	73
Frederick W. Schumacher Scholarship	†		75
S. Ubukata Fund	†		78
*Wallberg Undergraduate Scholarships (2)		\$ 500	79
Stewart Wilson Award	†		80

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR

(† indicates that application is required)

Harvey Aggett Memorial Scholarship		\$ 90	54
Ardagh Scholarship		\$ 600	56
A.S.H.R.A.E. Bursaries	†		55
Automotive Transport Association Bursary	†		56
Babb Bursary Fund	†		56
Canada Student Loans	†		58
Canadian Bechtel Limited Bursaries	†		57
J. P. Bickell Foundation Bursaries	†		58
J. P. Bickell Foundation Scholarships			57
T. H. Bickle Prize		\$ 30	58
Carveth Metallurgical Ltd. Bursary	†	\$ 500	59
5T6 Civils Scholarship	†	\$ 300	60
Crocker Foundation Bursaries	†		61
Cyanamid of Canada Scholarship		\$ 750	61
Dominion Auto Accessories Ltd. Scholarship		\$1000	61
John M. Empey Scholarship		\$ 170	62
Engineering Alumni Centennial Bursaries	†		62
Engineering Society Centennial Award		\$ 100	62
J. A. Findlay Scholarship		\$ 100	63
Hugh Gall Award	†	\$ 300	63
*General Motors Scholarships		\$1000	64
George A. Guess Scholarships			65
Hydro-Electric Commission of Ontario Bursary	†	\$ 500	66
I.B.M. Canada Bursary Plan	†		66
Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarships		\$ 200	68
J. Edgar McAllister Foundation Bursaries	†		67
*J. Edgar McAllister Foundation Undergraduate Awards		\$1000	67
Charles Gordon Manning Prize			69
James L. Morris Memorial Prize		\$ 175	70

Ontario Chapter American Society for Metals Bursaries	†	55
Ontario Chapter American Society for Metals Scholarship	\$ 500	55
Ontario Student Assistance Program	†	71
*Professional Engineers Scholarship	\$ 250	72
Rhodes Scholarship	† £1000	73
Frederick W. Schumacher Scholarship	†	75
Edith Tyrrell Memorial Bursary	† \$ 600	78
Wallberg Undergraduate Scholarship	\$ 500	79
William R. Worthington Memorial Scholarship	\$ 600	80

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR

(† indicates that application is required)

Stanley Irwin Allen Memorial Scholarship	\$ 300	54
American Institute of Industrial Engineers Scholarship	\$ 150	55
A.S.H.R.A.E. Bursaries	†	55
Babb Bursary Fund	†	56
F. W. Baldwin Prize	\$ 75	56
Canada Student Loans	†	58
Canadian Bechtel Limited Bursaries	†	57
J. P. Bickell Foundation Bursaries	†	58
T. H. Bickle Prize	\$ 30	58
*Chevron Standard Limited Scholarship	\$ 500	59
Chemical Institute of Canada Prize	\$ 25	59
Cominco Scholarships	† \$ 800	60
Sydney C. Cooper Bursaries	†	60
Crocker Foundation Bursaries	†	61
The Culliton Scholarship	\$ 300	61
Dow Chemical of Canada Limited Award	\$ 750	61
John M. Empey Scholarship	\$ 170	62
E.I.C. Prize	\$ 100	62
Engineering Alumni Centennial Bursaries	†	62
Engineering Society Semi-Centennial Award	\$ 100	63
J. A. Findlay Scholarship	\$ 100	63
James Franceschini Foundation Scholarship	\$ 300	63
George A. Guess Scholarships		65
Chester B. Hamilton Scholarship	\$ 500	65
I.B.M. Canada Bursary Plan	†	66
Loan Funds	†	80
J. Edgar McAllister Foundation Bursaries	†	67
*J. Edgar McAllister Foundation Undergraduate Awards	\$1000	67
J. A. D. McCurdy Prize	\$ 75	67
Alexander MacLean Scholarship	\$ 250	69

Ontario Chapter American Society for Metals Bursaries	†		55
Ontario Chapter American Society for Metals Scholarship		\$ 500	55
Ontario Student Assistance Program	†		71
*Professional Engineers Scholarship		\$ 250	72
RCE Memorial Scholarship	†	\$ 125	74
Rosedale Chapter, I.O.D.E. Award	†	\$ 400	75
Don Salt Memorial Scholarships	†	\$ 500	75
Murray F. Southcote Scholarship		\$ 100	77
Frederick W. Schumacher Scholarship	†		75
C. H. E. Stewart Bursaries	†		77
Peter S. White Memorial Bursary	†	\$ 950	79
Edith Tyrrell Memorial Bursary	†	\$ 600	78
Wallberg Undergraduate Scholarship		\$ 500	79

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR

(†indicates that application is required)

Henry G. Acres Medal			54
A. B. Platt Award, A.S.L.E.		\$ 75	55
J. P. Bickell Foundation Bursaries	†		58
Babb Bursary Fund	†		56
Canada Student Loans	†		58
Centennial Thesis Awards		\$ 50	59
Sydney C. Cooper Bursaries	†		60
Crocker Foundation Bursaries	†		61
IBM Canada Bursary Plan	†		66
Loan Funds	†		80
J. Edgar McAllister Foundation Bursaries	†		67
Massey-Ferguson Ltd. Scholarships (2)	†	\$ 250	70
Ontario Student Assistance Program	†		71
Otto Holden Scholarship		\$ 900	71
Professional Engineers Gold Medal			73
J. E. Reid Memorial Prize		\$ 50	73
Wallace Award, Society of Automotive Engineers Prize		\$ 100	77
Society of Chemical Industry Merit Award			77
"Second Mile Engineer" Award	†	\$ 200	76
C. H. E. Stewart Bursaries	†		77
W. S. Wilson Medals			80
Peter S. White Memorial Bursary	†	\$ 950	79

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other award as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examinations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

STANLEY IRWIN ALLEN MEMORIAL SCHOLARSHIP

Established by classmates and friends of the late Stanley Irwin Allen, B.A.Sc. 1961, this scholarship, of the value of \$300, is awarded to a student in Mechanical Engineering who has demonstrated high academic ability and outstanding scholarship in the work of the Third Year.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Toronto Chapter, American Institute of Industrial Engineers offers a scholarship of \$150 to a student entering the Four Year of the Industrial Engineering course. The student must have consistently maintained high, though not necessarily honour standing, during the previous three years, and must be an active member of the University of Toronto Student Chapter of A.I.I.E. The selection will be made on the recommendation of the Chairman of the Department of Industrial Engineering.

A.S.H.R.A.E. BURSARIES

The Ontario Chapter of the American Society of Heating, Refrigerating and Air Conditioning Engineers provides a number of bursaries, to a total value of \$1500 annually, for students in the Second and Third Years of Electrical Engineering and Mechanical Engineering. Candidates must reside in Metropolitan Toronto or in an adjacent municipality; the awards will vary in value, according to individual need and the fund available. Application should be made to the Secretary of the Faculty by November 15, on the regular in-course bursary application form.

A. B. PLATT AWARD, AMERICAN SOCIETY OF LUBRICATION ENGINEERS

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of \$75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory. The Prize is accompanied by a donation of \$25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARIES

The Ontario Chapter, American Society for Metals, provides several bursaries of a value of \$150 each for students in all years of Metallurgy and Materials Science and in the Third and Fourth Years of the Materials Science option of Engineering Science. Bursaries are awarded on the basis of academic ability and the need for financial assistance. Applications should be made to the Secretary not later than November 15. The first award was made for the Session 1958-59.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS SCHOLARSHIP

The Ontario Chapter provides one scholarship of a value of \$500 for academic excellence to be awarded to a student in Metallurgy and Materials Science after completion of the Second or Third Year, or the Materials Science option of Engineering Science (Third Year). The first award was based upon the results of examinations in the Session 1970-71.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from \$7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing with Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the office of Student Awards at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aerospace Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of \$75 was established by the trustees of a fund created by the members of Number 3 Squadron, University Air Training Corps (1941-44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aerospace Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953-54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the First Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to \$75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925-26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of \$1,200 to provide two or more awards, each of a minimum value of \$150. One award will be made to a First Year student and the remaining awards may go to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory of the Faculty Council.

Application must be made to the Secretary of the Faculty on or before November 15.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of \$1,500 payable \$500 in the First Year and provided honours are obtained at the annual Examinations, \$500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the University and must undertake to enroll in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned, students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of \$1,000, payable \$500 in each of the Third and Fourth Years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickell Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before November 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle Prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the Faculty of Arts, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of \$250 and a maximum of \$1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards in April on the regular admission scholarship application form.

CANADA STUDENT LOANS PLAN

Full details of this Plan are available in a brochure issued each spring by the Government of Canada. Basically, the plan is designed for those students who have resided in Canada for twelve months and demonstrate financial need, but who do not qualify for assistance under the Ontario Student Assistance Program. Effective 1972, the maximum Canada

Student Loan is \$1,400 per academic year. The application form for the Ontario Student Assistance Program is also used for the Canada Student Loans Plan.

Application forms and brochures are available from the University of Toronto, Office of Student Awards, and all other post-secondary institutions, and should be submitted to the institution which the student plans to attend.

Students who intend to study outside Ontario or abroad should apply through the Ministry of Colleges and Universities, Mowat Block, Queen's Park, Toronto, Ontario.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of \$500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961-62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Application should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CENTENNIAL THESIS AWARDS

In honour of the Centennial of the founding of the Faculty in 1873, the Centennial Thesis Awards were established in 1972-73 to recognize excellence in Fourth Year thesis work. One award is made annually in each of the Faculty's eight degree programs, based on departmental recommendations, the award being in the form of a \$50 prize and accompanying framed certificate. Original finding was provided through the Office of the Dean and is being continued through the generosity of the University of Toronto Engineering Alumni Association.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of \$25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of \$500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering (even years) and Arts and Science (odd years). The First Award was made in the session 1960-61 in the Faculty of Applied Science and Engineering.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of \$300 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of \$800 each, are provided by Cominco Limited and are offered to students in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

SYDNEY C. COOPER BURSARIES

An amount of \$900 is provided annually for bursaries to be awarded to students in the Third and Fourth Years of the program in Civil Engineering who have achieved at least second-class standing in the previous year and who are in need of financial assistance.

Application must be made on the regular in-course bursary application form not later than November 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than November 15.

THE CULLITON SCHOLARSHIP

Mr. Peter J. Culliton, B.A.Sc., 2T1, M.A.Sc., 2T3 (Civil Engineering), has graciously donated a sum of \$1500 to the Faculty to be used to fund this award. The scholarship, first awarded in 1973-74 will have a value of \$300 annually until 1978-79, when the fund will have depreciated and a smaller final award will be made. The scholarship is awarded to the student in Civil Engineering who achieves the highest standing at the annual examinations of the Third Year among those who do not hold an award of higher value.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their program to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of \$750 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

DOMINION AUTO ACCESSORIES LTD. SCHOLARSHIP

Supported by an annual donation from the Buck Family Foundation, this scholarship, of the value of \$1000, is awarded to a student entering the Third Year in Industrial Engineering who has achieved high standing, with honours, on the work of the Second Year.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited has provided funds for an annual award of \$750 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and a grant-in-aid of \$250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

- (a) be registered in the Third Year in Chemical Engineering (the award will be made in the second term of the Third Year and will be paid to the winner during his Fourth Year);
- (b) be in the upper half of the class;
- (c) have demonstrated leadership in extra-curricular activities.
- (d) have a sincere interest in the chemical industry.

The award is not tenable with other awards in the gift of the Governing Council. Application is not required.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of \$10,000 in the Will of the late John Morgan Empey, B.A.Sc., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the awards shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI CENTENNIAL ADMISSION SCHOLARSHIPS

Seven scholarships, each of the value of \$1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the First Year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards in April on the regular admission scholarship application form.

ENGINEERING ALUMNI CENTENNIAL BURSARIES

Thanks to the generosity of the Engineering Alumni Association, a number of bursaries have been established in the Faculty of Applied Science and Engineering. These bursaries are awarded on the basis of academic achievement and financial need, with preference being given to students in the Third and Fourth Years.

Application should be made to the Secretary of the Faculty not later than November 15.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada Prize, of the value of \$100, is awarded annually to a Student Member of the Institute on the basis of the marks made at the completion of his penultimate year of undergraduate study, and on his activities in the Engineering Society or in the student branch of a recognized engineering Institute or similar organization.

ENGINEERING SOCIETY CENTENNIAL AWARD

The Engineering Society Centennial Award, to the value of \$100, was established in 1973 to commemorate the Centennial of the founding of the School of Practical Science. The award is made to a student entering the Second or Third Years.

The selection is based on the following qualifications, which each bear equal weight in the selection of the winner: (a) General "Skule" activities; (b) Contributions to the Engineering Society Council; (c) Personality, and social and athletic activities. The winner must obtain an unconditional pass standing on the work of the year.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, currently having a value of \$100, was established in 1931 to commemorate the first graduating class of the School of Practical Science. The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (a) General "Skule" activities; (b) Contributions to the Engineering Society Executive Committee; (c) Personality, and social and athletic activities; (d) Academic Standing.

J. A. FINDLAY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this Course, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third years respectively, but in making the award the student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of \$300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of \$100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award was established in 1946 by the graduate Class of 1910 "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career."

Upon expiration of the original gift in 1951 the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of \$5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest. The award is made to a student who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the Second Year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any Second Year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than November 15.

THE GENERAL MOTORS SCHOLARSHIPS

Provided by General Motors of Canada Ltd., a scholarship of \$1,000 is awarded annually to the student entering the Third Year of the program in Mechanical Engineering, who being a Canadian citizen, has demonstrated the highest academic and leadership qualities. The scholarship is renewable for the Fourth Year, provided that the recipient maintains satisfactory academic standing. Another scholarship of equal value is awarded annually to a student in the Faculty of Arts and Science.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately \$500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one year's instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form in April.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship was first awarded in 1945 in memory of the sons of Lieutenant-Colonel E. W. Hagarty and Charlotte Ellen Hagarty, his wife. It has the value of the annual interest on the capital sum of \$2,000 and is awarded to a student who has completed Grade XIII at Harbord Collegiate Institute. Further details are available from, and application should be made to, the Office of Student Awards in April.

THE GEORGE A. GUESS SCHOLARSHIPS

The estate of Edna F. Guess, wife of George A. Guess, formerly Head of the Department of Metallurgical Engineering, has bequeathed funds to the University for the purpose of establishing the George A. Guess Memorial Fund for the assistance of needy students of Metallurgy. The annual income of the Fund is used to provide graduate fellowships, summer studentships and an undergraduate fund in the Department of Metallurgy and Materials Science in addition to the George A. Guess Scholarships.

A maximum of six George A. Guess Scholarships may be awarded annually, each having a value of the regular tuition and incidental fees. The awards are made to students who have achieved high academic standing (not less than 80%) who are in need of financial assistance, and who do not hold another academic award.

Three awards are made to students entering the Second, Third or Fourth Years of Metallurgy and Materials Science, two awards to students entering the Third or Fourth Years of the Materials Science Option of Engineering Science and one award to students entering the Third or Fourth Years of the Mineral Engineering Option of Geological Engineering. If there are insufficient numbers of qualified students in any of the eligible programs, then the remaining awards may be distributed to qualified students in either of the other two programs. If six awards are not made in any year, the residual sum will remain in the George A. Guess Fund to be used for one of the purposes stated above. The first awards will be made on the results of the examinations of 1974-75.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of \$500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958-59.

THE MURRAY CALDER HENDRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of \$10,000 and the recipient must:

- (a) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.
- (b) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards in April on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962-63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of \$500 each, to be awarded to students who have achieved high standing on the Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hydro-Electric Power Commission of Ontario has provided a bursary of the value of \$500, which may be awarded to a student entering the Second Year of the courses in Mathematics and Physics or Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than November 15.

IBM CANADA BURSARY PLAN

International Business Machines Company Limited has made available one or more bursaries of a total annual value of \$1,000 to students registered in any year of a full time course in the University who have standing satisfactory to the Committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by November 15.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of \$800 in each of the Second, Third and Fourth Years or a total possible value of \$2,400.

The recipient must:

(a) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;

(b) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;

(c) in his Second and Third Year, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

J. EDGAR McALLISTER FOUNDATION BURSARIES

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty in 1895, a fund has been established in the University to be known as the J. Edgar McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science. Application should be made on the regular in-course bursary form not later than November 15.

J. EDGAR McALLISTER FOUNDATION ADMISSION AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., twenty-five awards of the value of \$1,000 each are available to students entering the First Year of the programs in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science, who have achieved high standing in the secondary school courses prescribed for admission and who are in need of financial assistance.

Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto Scholarship Application form, which is to be submitted in April.

J. EDGAR McALLISTER FOUNDATION UNDERGRADUATE AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., five awards of \$1,000.00 each are available to students entering the Second Year in Chemical, Electrical, Geological and Mechanical Engineering, and Metallurgy and Materials Science, who have achieved honours standing in the work of the preceding year. Normally one award will be made in each of the eligible programs, but in the absence of a suitable candidate in a particular program, two awards may be made in another. The bequest also provides for five awards to students entering Third Year, and five to students entering the Fourth Year of Chemical Engineering or the Chemical Option of Engineering Science; Electrical Engineering or the Electrical Option of Engineering Science; Geological Engineering or the Geophysics Option of Engineering Science; Mechanical Engineering or the Nuclear and Thermal Power Option of Engineering Science; and Metallurgy and Materials Science or the Materials Science Option of Engineering Science.

These awards are not tenable with any other scholarships.

THE J. A. D. McCURDY PRIZE

The J. A. D. McCurdy Prize of a value of \$75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941-44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aerospace Option, in

Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953-54.

THE GARNET W. MCKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachland Gilchrist each contributed \$1,000 to provide for a Scholarship in the First Year of the course in Engineering Science.

The value of the Scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours at the annual examinations of the First Year in the course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the course. In order to receive payment the winner must register in the Second Year of the course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. MCKEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachland Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Governing Council, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachland Gilchrist Geophysics Scholarship. This scholarship, of the annual value of \$200 is awarded to the student in the Second Year in the course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of \$165 is awarded to the student in the Second Year in the course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fulfilled the condition as laid down for the

Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES McKELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of \$500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MACLEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954. The scholarship, of the value of \$250, is awarded to a student in the Third Year of Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering, Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MACLENNAN-MACLEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known as "The MacLennan-MacLeod Memorial Prize," in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, their first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of \$25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Algebra, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in the subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of \$500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the pass requirements in his Department and being "adjudged highest of the three in general student activities and service in the University during his period of attendance."

The first award was made on the results of the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of \$250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than November 15.

GEORGE R. MICKLE ADMISSION BURSARIES

Provided for by a bequest of the late George R. Mickle, five bursaries of the value of \$1,000 each are available to students entering the First Year of courses in the Faculty of Applied Science and Engineering. The awards are made on the basis of the applicant's academic standing in Grade XIII, and his need for financial assistance. Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto admission awards application form.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career.

Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal power and bridge work.

This Prize, of the value of the annual income from \$3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death, Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied Science and Engineering. This scholarship, which has a value of approximately \$900 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967-68.

ONTARIO STUDENT ASSISTANCE PROGRAM

All students who are attending eligible post-secondary institutions in Ontario may qualify for assistance under this program provided that they satisfy the residence requirements as outlined in the Ontario Student Assistance brochure and demonstrate financial need. An award under this Program will be made to the extent of established need in a combination of a non-repayable grant and a Canadian Student Loan. Application forms and brochures for the 1975-76 Program will be available early in May, 1975. They may be obtained from the University of Toronto, Office of Student Awards, and all other post-secondary institutions. Applications should be submitted in person at the institution which the student plans to attend.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I or II.

The value of this scholarship is \$100 in cash, with an allowance of the same amount on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but *coeteris paribus*, the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Governing Council of the University upon the report of a Committee to be appointed, upon which Committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form in April.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother, John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of \$10,000, approximately \$550 annually, is awarded to a student who obtains high standing in the work of the First Year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least Second Class Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before November 15.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of \$500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards in April, on the regular admission scholarship application form.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of \$250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of \$50. The award will be made to the student of the final undergraduate year in any course who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering is presented by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of \$5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the course in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and be unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year for which he is elected; he must have completed the first year of his course at a Canadian University at the time of application.

A candidate may apply either for the province in which he has his private home or residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr. Rhodes mentioned four groups of qualities, the first of which he considered most important.

- (1) Literary and scholastic attainments;
- (2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness, unselfishness, and fellowship;
- (3) Exhibition of moral force of character and of instincts to lead and to take an interest in his fellows;
- (4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or in any combination of these, is the most important requirement. Financial need does not receive special consideration.

Forms of application and full information regarding these scholarships may be obtained from the Director, Office of Student Awards, University of Toronto, or from Arthur R. A. Scace, Esq., General Secretary for the Rhodes Scholarships in Canada, Box 48, Toronto Dominion Centre, Toronto. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R.C.E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of \$125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A Candidate must be:

- (a) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or
- (b) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or
- (c) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of \$125 and a living allowance of \$240 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given to applicants from outside Ontario but failing such candidates, awards may be made to qualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of \$200 and a maximum of \$1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards in April on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical Society has provided two scholarships of the value of \$500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology and Applied Earth Science by March 1 in the calendar year in which the award is to be made.

ROSEDALE CHAPTER I.O.D.E. AWARD IN ENGINEERING SCIENCE

An award of \$400 will be made annually to a student enrolled in the Third Year of the program in Engineering Science, on the basis of academic standing and financial need. Recipients must be Canadian citizens, but not necessarily residents of Ontario.

Application should be made to the Secretary of the Faculty on the regular in-course bursary application form not later than November 15.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been established in the Faculty of Applied Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (a) be enrolled in the Second, Third or Fourth Years in Geological Engineering in the

Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and (b) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later than November 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionally competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called "The Second Mile," which was based on the text from the Sermon on the Mount, "whosoever shall compel thee to go one mile, go with him twain", has established the "Second Mile Engineer" award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of \$200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award, consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, the Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of \$100 is available for each of the schools mentioned and an additional sum of \$50 will be given to the student who obtains the highest percentage of Grade XIII subjects selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD

SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto, the Ontario Society of Automotive Engineers offers an annual prize of the value of \$100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Chairman of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of \$100, is awarded in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964-65.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain First Class Honours standing on the Ontario Grade XIII papers required for admission and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from \$200 to \$1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than \$200 is desired.

C. H. E. STEWART BURSARIES

Under the provisions of the will of the late Mary Jones Stewart a sum of \$10,000 was bequeathed to the University, the income of which is to be used to provide a number of bursaries in denominations of \$50, \$75 and \$100 to students in the Third and Fourth Years

of courses in the Faculty of Applied Science and Engineering, the awards to be made on the basis of financial need, scholastic ability and general character, with preference being given to students who are descendants of veterans of the First and Second World Wars. Applications should be submitted to the Secretary of the Faculty by November 15, on the regular in-course bursary application form.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of \$600, annually, commencing in 1939, and named in memory of their founder and president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special Committee appointed by the Association on the following basis:

- (a) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.
- (b) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.
- (c) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:

- (a) must be Japanese students from Japan proper;
- (b) must register in the University of Toronto devoting full time to their studies;
- (c) are able to satisfy admission requirements regarding English facility;
- (d) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of \$500 annually, and are tenable for two years, providing satisfactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the Committee of Award will take into consideration

the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the Committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Office of Student Awards not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

WALLBERG ADMISSION SCHOLARSHIPS

Six admission scholarships, each of a value of \$1,000 are awarded annually from the income from the Wallberg Bequest on the recommendation of the Council of the Faculty to the six candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The Scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other admission scholarship.

Applications must be submitted to the Office of Student Awards in April on the regular admission scholarship application form.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of \$500 each, derived from the Wallberg Bequest, are awarded annually: two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

PETER S. WHITE MEMORIAL BURSARY IN EARTH SCIENCES

Donated by the Texas Gulf Sulphur Company in memory of the late Peter S. White, B.A.Sc. 1956, this bursary of the value of the tuition fee plus \$100, is open to students in the Faculty of Arts and Science (in Geology, Physics and Geology or Physics) and in the

Faculty of Applied Science and Engineering (in the Mineral Exploration Option of Geological Engineering or the Geophysics Option of Engineering Science). The award will be made on the basis of scholastic ability and financial need. Application should be made on the regular in-course bursary form not later than November 15.

THE STEWART WILSON AWARD

This award is available through the generosity of the Engineering Alumni Association. Its value fluctuates to cover the residence fee of New College (\$1,056 in 1973-74). The first award was made in 1965-66. It is open to students who, proceeding to the Second Year of any course in the Faculty of Applied Science and Engineering, were resident or non-resident members of New College during their First Year. The award is based upon academic ability, leadership qualities, contribution to New College activities and financial need. The award winner shall reside in the Stewart Wilson Room of New College during the academic year of his tenure.

Application should be made to the Registrar of New College by March 31, and announcements regarding a successful candidate will be made by August 1.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962-63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother William R. Worthington, DIPL. (1904), B.A.Sc. (1905), of the value of the income from the fund, is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examination for the Session 1954-55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Inquiries for loans from any of the following funds should be made at the Office of the Secretary of the Faculty.

Engineering Society Loan Fund

James W. Crocker Memorial Fund

Harry F. Bennett Educational Fund

S. A. E.-Canadian Section Loan Fund

Avro Aircraft Limited Engineering Loan Fund

The William Storrie Memorial Fund

3T6 Engineers Loan Association

4T0 Engineering Loan Fund

The Devonshire Loan Fund

Class of '09 Trust Fund

University of Toronto Alumni Loan Fund

Wallberg Memorial Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee appointed by the Governing Council. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the Office of the Secretary of the Faculty.

JAMES W. CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of the Engineering Institute of Canada in memory of the late Harry F. Bennett. M.E.I.C., who for six years prior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study Engineering Science at University level, and who have proved themselves by successfully completing their First Year in Engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in Engineering Science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF THE AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of \$1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in Fourth, Third and Second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft has established a loan fund of \$3,000 to provide loans to Engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This fund has been established by Graduates and friends of Devonshire House to assist students in the Residence. Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

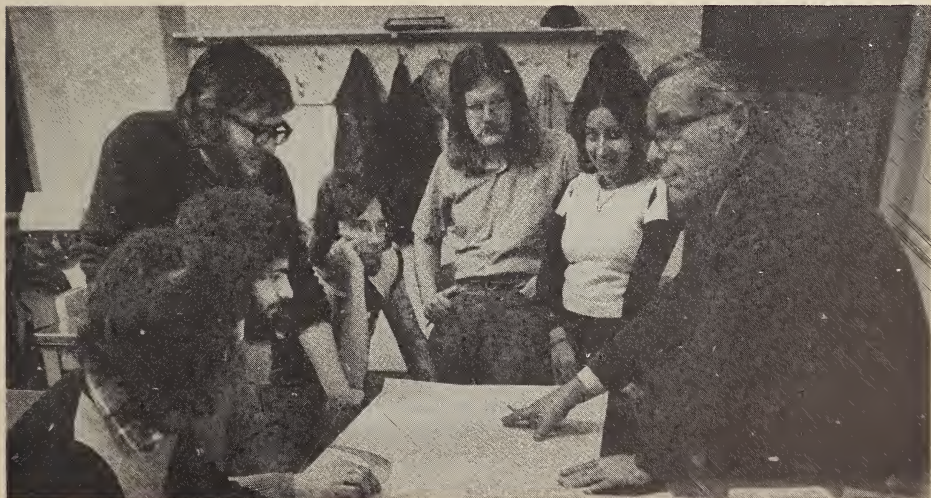
The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in Second and subsequent years. Funds are available for emergency purposes only.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.



FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below. The total fee in each case is made up of the academic fee and incidental fees; all incidental fees are payable in the First Term.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session, it is recommended that at least the First Term instalment of fees be forwarded by return mail before August 15.

Fees may be paid by certified cheque, money order or personal cheque payable to the University of Toronto in Canadian funds, and mailed to the Office of the Comptroller, University of Toronto, Toronto M5S 1A2.

2. Payment of at least the First Term instalment must be made before the opening day of the session. A registration card cannot be issued until the student has complied with this requirement.

3. The Second Term instalment of fees, if not already paid, is due on the opening day of the Second Term and must be paid not later than January 15. After this date a penalty of \$10 will be imposed. As of March 1, an additional charge of 1.5% per month will be imposed. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Fees, residence dues and other charges set forth in this calendar are subject to change by the Governing Council.

SCHEDULE OF FEES

Academic Year	Academic Fee ¹	Inci- dental Fees ²	Total Fee (if paid in one instalment)	First Term Instalment	Second Term Instalment
I-IV.....	\$750	\$84.50	\$834.50	\$546.50	\$300

1. The Academic Fee includes the following fees: Tuition; Library and Laboratory Supply; Annual Examinations; Laboratory Fees; and Degree.

2. These Incidental Fees include the following fees: Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.

FEE FOR RE-CHECKING MARKS

A student who requests that his marks be re-checked must submit with his request a fee of five dollars (\$5) for each paper to be checked. The fee is refunded if an error is found.

FEE FOR TRANSCRIPTS

Transcripts of academic record are furnished by the Faculty Office on payment of a fee of \$1.50 for a single copy plus 50 cents for each additional copy requested on the same order.

SPECIAL STUDENTS' FEES

The fee is \$115 per course, plus incidental fees of \$7.00 per session for Hart House and A.P.U.S.

PENALTY FOR LATE REGISTRATION

Any student who registers after the last date for normal registration must petition for acceptance of his registration and is required to pay a late registration fee as follows:

If registering within 7 calendar days-\$10

If registering after 7 calendar days-\$20

PENALTY FOR LATE SUBMISSION OF PROGRAM DOCUMENTS

A student who fails to submit his program documents (e.g pre-registration, course selection or examination application forms) by the prescribed date will be subject to a fine of \$1 for each day beyond the deadline to a maximum of \$20.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule on preceding page.
2. Board and lodging, per week.....\$40 up
3. Books and instruments, per year.....\$200 up

EVALUATION AND PROMOTION

I. DEFINITIONS

Fall Term Average - is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term, with the weighting factor for each course being the units assigned to it. The results of full-year courses will not be included in the calculation of the Fall Term Average.

Spring Term Average - is calculated on the basis of all courses in which the student is enrolled at the start of the eighth week of the term with the weighting factor for each course being the units assigned to it. The results of full-year courses will be included in the calculation of the Spring Term average with a weight equal to the sum of the fall and spring term weights.

Summer Courses, Part-Load Students - Students who in any term take less than the minimum full-time load, which is normally 40 weight units, shall be deemed to be part-load students. Not included in this category are students of Woodsworth College registered as part-time students, or students in their final term who fall under Regulation 2(e). The results of courses taken by part-load students will not be averaged, and no promotional evaluation will be made on their work. Any course taken by such student in which a mark of 60% or better is obtained will be credited to the student, exempting him from the equivalent course requirement in his regular full-time program. No credit will be retained for courses in which lower marks are obtained. (Approval to take a summer course for credit or to proceed as a part-load student must be obtained in advance by writing to the Secretary, Faculty of Applied Science and Engineering.)

Core Course - Any course in a program that is so designated by a Department.

Evaluation Period - The evaluation period is a single term.

II. PROMOTION REGULATIONS

1. To qualify for a degree, a student must complete a full undergraduate program.

- 2.(a) The normal load is 48 units per term but a student may reduce his load to approximately 40 units or increase it to 60 units if his Department Chairman approves.
- (b) Certain students are not permitted to reduce their academic loads, viz. students in First Year for the first time, or students who are required to repeat all of the courses in a term of one of the prescribed departmental programs.
- (c) Students required to repeat courses and to whom regulation 2(b) does not apply must carry a reduced load of approximately 40 units per term.
- (d) In the final term a student may carry less than the normal minimum load of 40 units if the aggregate weight of the courses required for completion of his program is less than 40 units.
- (e) To be eligible for graduation a student must attain an average not less than 60% in his final term; a student who fails to do so must repeat or replace courses to bring his average up to at least 60%.
3. The regulations for promotion and failure are shown in tabular form at the end of this section. The rules pertaining to re-admission after suspension or failure are given in Regulation 4 below. The rules pertaining to courses which must be repeated are given in Regulations 5 and 6 below.
4. A student who has been suspended for a specified period of time will automatically be re-admitted on request after expiry of the suspension. A student who has been required to withdraw does not have an automatic right of re-admission but may apply for re-admission as follows:
- (a) A student who has been required to withdraw for the first time as a consequence of his standing in the work of a term (Fall or Spring) may apply for re-admission to the corresponding term in the next session or in a subsequent session.
- (b) A student who has been required to withdraw from the First Year Engineering Science program will not normally be re-admitted to the Engineering Science Program, but will be considered for re-admission to any other engineering program.
- (c) Each application for re-admission is considered on its merits, in competition with all other applications.
- (d) If re-admitted, the student is placed on probation and is required to repeat all courses (or their equivalents) in which he obtained less than 60 marks in his last evaluation period. (See Regulation 6).
- (e) A student who is required to withdraw for the second time will not normally be re-admitted.
5. A student required to repeat courses can make up his academic load of approximately 40 units per term in the following ways, provided that his selections create no timetable conflicts:
- (a) By taking courses from the next higher year of the program if he has obtained a mark of 50% or greater in the appropriate prerequisite taken in his previous evaluation period.

(b) By taking course of comparable level to his failed courses. Normally these will not relieve the student of completing all the required courses in the program in which he is enrolled.

(c) By repeating courses which he has previously completed.

6. A student required to repeat a course which is not designated as a core course can instead replace it by a course of comparable level.

REGULATIONS FOR PROMOTION AND FAILURE

	<u>Term Average (A)</u>	<u>Decision</u>
ENGINEERING PROGRAMS		
Term 1F	A $\geq$ 60%	Passed - proceed to next term.
	60% > A $\geq$ 50%	Proceed to next term on probation ¹ .
	50% > A	Failed - required to withdraw.
All other terms	A $\geq$ 60%	Passed - proceed to next term.
	60% > A $\geq$ 55%	Proceed to next term on probation ¹ .
	55% > A $\geq$ 50%	Proceed to next term on probation ¹ , repeat ² all courses with marks less than 60%.
	50% > A	Failed - required to withdraw.
ENGINEERING SCIENCE PROGRAM		
Term 1F	A $\geq$ 60%	Passed - proceed to next term.
	60% > A $\geq$ 50%	Passed - proceed to next term in another program.
	50% > A	Failed - required to withdraw.
Term 1S	A $\geq$ 66%	Passed - proceed to next term.
	66% > A $\geq$ 55%	Passed - proceed to next term in another program.
	55% > A $\geq$ 50%	Proceed to next term in another program on probation ¹ .
	50% > A	Failed - required to withdraw
All other terms	A $\geq$ 60%	Passed - proceed to next term.
	60% > A $\geq$ 55%	Proceed to next term on probation ¹ .
	55% > A $\geq$ 50%	Proceed to next term on probation ¹ , repeat ² all courses with marks less than 60%.
	50% > A	Failed - required to withdraw

¹Unless the Student entered the term on probation, or has been on probation twice before, in which case he has failed and is required to withdraw.

²A student in this category who must repeat more than two of this technical courses is deemed to have failed and is suspended for one term.

III TRANSFER OF PROGRAM

1. Transfers within the Faculty:

A student may be permitted to transfer from one program to another in the Faculty of Applied Science and Engineering, subject to the following conditions and exceptions. Application to transfer must be made on a Request for Transfer Form available at the Faculty Office.

(a) Transfers at any level are subject to the availability of places, except that students who have satisfied the requirements for promotion in Engineering Science at the end of Term 1F or 1S may transfer to any other program within the Faculty without restriction.

(b) A student in Term 1F in Engineering Science may apply for immediate transfer to an Engineering program up to the last date for adding or substituting Fall Term courses. Thereafter he may not apply to transfer until the end of Term 1F or Term 1S.

(c) Applications of First Year students to transfer from one Engineering program to another will be considered at the end of Term 1S when the number of available places in each second-year program is known. In the case where the number of applicants exceeds the number of places available in a program, selection will be made during the period April 15 to June 30.

(d) Transfers from Engineering programs to Engineering Science are not permitted except in extraordinary cases.

(e) Transfers after the beginning of the Second Year will normally involve curriculum adjustments to remedy deficiencies.

2. Transfers to other Faculties:

A student interested in transferring to another Faculty or School in the University of Toronto should consult with the Secretary of the Faculty or School concerned in regard to the feasibility of transferring.

IV GRADING SYSTEM

1. Course Grades

Marks	Grade
80 - 100%	1
70 - 79%	2
60 - 69%	3
50 - 59%	4
35 - 49%	5
Below 35%	6

2. Course Credit

(a) Promoted students retain credit for all courses on which a grade of 5 or higher has been obtained.

(b) Students who have failed to secure promotion retain or who are taking a part-load retain credit only for those courses on which a grade of 3 or higher has been obtained.

(c) Notwithstanding the mark obtained by a student in a course, the examiner may report the grade as "Incomplete" if some part of the course work has not been performed. Upon confirmation of the incomplete status by the Committee on Examinations, the student will be required to complete the course work to the satisfaction of the examiner before the end of the subsequent term.

3. Honour Standing

(a) Honour standing in the work of the term or a year is granted to students who achieve a weighted average of 75% or greater.

(b) Honour graduate standing will be granted to students who obtain honours in the final year and in one other previous year.

4. Checking of Marks

It is a policy of the Faculty that no examination papers or essays will be re-read or re-evaluated after the results have been issued. All results are carefully reviewed before being released. However, the clerical work involved in the examining department and in the Faculty Office will be checked upon written request to the Secretary of the Faculty of Applied Science and Engineering. The request must be accompanied by a fee of \$5 for each paper to be checked. The fee will be refunded if an error is found.

5. Penalties for Lateness

Due dates, manner of submission, and penalties for failure to comply are normally prescribed by staff members for all work required to be submitted by students for credit in any course. This includes, inter alia, problem sets, essays, laboratory reports, design reports, drawings and theses. Suitable notification of such due dates and penalties is provided, for example, by posted notices or in instruction sheets distributed at scheduled classes.

GENERAL REGULATIONS

I ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance or work is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports, briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the time table.

II APPEALS

1. A student should submit immediately after its occurrence, evidence of any illness or mishap which occurs during the term; any petition for leniency on account of such incidents may be refused consideration if received after the third day following the last day of examinations.

2. A student wishing to appeal against a decision of a Committee of Council should consult the Secretary of the Faculty for information regarding the appeal processes available within the Faculty.

3. A student wishing to appeal to the Governing Council against a decision of the Council of the Faculty should consult the Secretary of the Faculty or the Secretary, Sub-Committee on Academic Appeals, Office of the Governing Council, about the preparation and submission of his petition to the Secretary of the Governing Council.

4. The University Ombudsman investigates grievances or complaints against the University, or anyone in the University exercising authority, from any member of the University - student, faculty or administrative staff. He assists in any way he can in resolving grievances or complaints, and can recommend changes in academic or administrative decisions where this seems justified. In handling a grievance or complaint, he has access to all relevant files and information, and to all appropriate University officials.

The Ombudsman also provides information to members of the University about their rights and responsibilities, and the procedures to follow in order to pursue whatever business or complaint they may have. All matters dealt with by the Ombudsman are handled in a strictly confidential manner unless the individual involved approves otherwise. The Ombudsman is independent of all administrative structures of the University, and is accountable only to the President and the Governing Council.

For information, advice or assistance, contact the office of the University Ombudsman, University of Toronto, 16 Hart House Circle, Toronto, Ontario M5S 1A1 (Telephone 978-4874.)

III EXTRA-CURRICULAR ACTIVITIES AND ACADEMIC CREDIT

It is in general desirable for students to engage to a reasonable extent in extra-curricular activities in order that they may not become too narrowly professional in interests and outlook, but it will be obvious that no academic credit or consideration can be given for such activities. Some offices in student organizations require quite large amounts of time for the proper performance of the duties connected with them, and it is therefore strongly recommended that students, particularly those whose academic records are not high, consult a senior member of staff before allowing themselves to be nominated for such offices.

IV DISCIPLINE

(a) Academic

The Governing Council of the University of Toronto has approved a Code of Behaviour regarding academic discipline applying to all students and members of the teaching staff of the University. This Code describes the rights and freedoms to be enjoyed by members of the University. It also lists forms of behaviour regarded as academic offences in the University, and the sanctions for such offences. Examples of such offences include plagiarism, cheating in examinations, the evaluation of a student's work by irrelevant criteria, etc. Such offences may be referred to the University Disciplinary Tribunal and to other relevant disciplinary bodies in the University.

The full text of the Code of Behaviour and the Governing Council Enactment concerning the Disciplinary Tribunal can be obtained from college and faculty offices, the office of the Vice-President and Provost, the office of the Secretary of the Governing Council, and that of the Chairman of the University Disciplinary Tribunal.

(b) Discipline in non-academic matters

The Councils of University College, Scarborough, Erindale, New and Innis Colleges, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools and Institutes have disciplinary jurisdiction over the conduct of all students registered in these divisions of the University in all matters of local or internal concern to the divisions. Jurisdiction over the conduct of students while in residence rests with the body administering the residence.

Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University, requires confirmation of the Governing Council. The role of Caput and the various Councils as described above is contingent on the understanding that offences or actions or claims within the jurisdiction of criminal and civil courts will be referred where appropriate to those courts and will only be reviewed by the Caput where the implications to the University are considered sufficiently important to warrant such review.

V CAMPUS ORGANIZATIONS

Responsibilities for recognition of organizations where the membership is drawn from a single College, Faculty or School rests with the Council of that division. Where campus-wide organizations (or organizations drawing members from more than one division or constituency of the University) are

concerned, responsibility is vested in the Internal Affairs Committee of the Governing Council.

Eligibility for recognition is assessed annually. The constitutions of every society or association, and subsequent amendments to such constitutions, shall be submitted to the appropriate administrative officer for perusal. The objectives and activities of groups seeking recognition should be seen as attempting to contribute to the educational, recreational, social or cultural values of the University. Membership in groups should be open to all members of the University community without restriction on the grounds of national origin, race, religion, colour, or sex. Status as non-voting members may be extended to interested persons from outside the University.

The curriculum is based upon a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) are one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. Students are evaluated for promotion at the end of each term.

The curriculum provides a good deal of latitude to the student in choosing his program of study. A regular program normally consists of a maximum of six courses per term with a total weight of 48 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 40 units per term, or to increase it to a maximum of 60 units per term.

On the following pages of this section the curriculum of each program is set forth in detail. A common curriculum for students in First Year (in First and Second Years in Engineering Science) forms a basis in the fundamental subjects prior to subsequent specialization in various Engineering disciplines. The student is able to choose from a wide range of technical electives in the senior years, and in the Fourth Year, all programs contain a thesis, which provides the student with the opportunity to carry out original work in his chosen field of study.

As a guide to students in apportioning their time, a weight factor is shown opposite each course of instruction. The weight factor represents the number of hours per week, including both scheduled class-room time and home work, that the average student is expected to devote to that course. This weight factor is also used in the computation of the student's weighted average in the work of the term.

The program and regulations contained in this Calendar hold good for this academic year only, and the Faculty of Applied Science and Engineering does not bind itself to adhere for the whole period of a student's attendance to the conditions here laid down. The Faculty reserves the right to withdraw any course for which there is insufficient enrollment or resources, and to limit the enrollment in any course.

ELECTIVE COURSES

Elective courses fall into four categories, viz. Technical Electives; Non-Technical Electives (in First and Second Year); Open Electives (in Third Year) and Free Electives (in Fourth Year). In general, the student must not select elective courses which would involve excessive duplication of material covered elsewhere in his program. The following paragraphs provide further instructions on the selection of elective courses:

1. TECHNICAL ELECTIVES: These are specified in the prescription for the program in which the student is registered. In most cases the choice is restricted to a specified list of available Technical Electives. The availability of a particular elective course may depend on a sufficient number of students wishing to take it; in a few courses it may be necessary to limit the number of students enrolled.

2. NON-TECHNICAL ELECTIVES (First and Second Year): Each student must include a Non-Technical Elective in each term of his First Year program and in one term of his Second Year program. In general, acceptable Non-Technical Electives have as their central theme the study of man as an individual or of man as a social being. Courses that are not acceptable are those that have an appreciable mathematical, skills, or technical content.

The following courses have been arranged specifically for students of the Faculty of Applied Science and Engineering, and have been scheduled on Monday, Wednesday and Friday at 1, so as to be available to all students. The work load in these courses is compatible with the student's work load in Engineering courses.

ENG 281F/S	Effective Writing
ENG 282F/S	Twentieth Century Literature I
ENG 283F/S	Canadian Literature I
ENG 284F/S	Varieties of Fiction I
ENG 285F/S	Drama and the Modern Theatre I
ENG 286F/S	Literature and Science I
ENG 292S	Twentieth Century Literature II
ENG 293S	Canadian Literature II
ENG 294S	Varieties of Fiction II
ENG 295S	Drama and the Modern Theatre II
ENG 296S	Literature and Science II
HPS 280F	History of Science
HPS 281F	History of Technology and Engineering up to the Industrial Revolution
HPS 282S	History of Technology and Engineering from the Industrial Revolution to the Present
HPS 283S	Technology, Engineering and Society
HPS 480S	Seminar on the Evolution of Technology
PHL 291F	Science and Society
PHL 292S	Science and Philosophy

Students desiring a broader choice in their Non-Technical Electives may obtain from the Faculty Office or their Departmental Offices, information concerning courses offered by the Faculty of Arts and Science and other faculties and schools in the University which are acceptable as Non-Technical Electives. These courses encompass a broad range, including languages, history, philosophy, anthropology, psychology, economics, political science, etc. Students are cautioned that some of these courses may require a larger commitment of time than those courses which have been arranged specifically for the Faculty of Applied Science and Engineering.

3. OPEN ELECTIVES (Third Year only): In each term of the Third Year there is provision for an Open Elective which the student must fill. Courses acceptable as Open Electives are (i) any course which is acceptable as a Non-Technical Elective as defined above, or (ii) excluding courses offered by the Faculty of Applied Science and Engineering, any degree credit course listed in a current calendar of the University of Toronto, its constituent colleges, federated colleges, or federated universities. Students

selecting courses in category (ii) must obtain the approval of the teaching department offering the course.

A student in the Third Year whose technical program involves 16 or more units per term taken outside the Faculty may be permitted to choose a course offered within the Faculty as his Open Elective.

4. FREE ELECTIVES (Fourth Year only): In each term of the Fourth Year there is provision for a Free Elective which the student must fill. Any degree credit course listed in a current calendar of the University of Toronto, its constituent colleges, federated colleges, or federated universities is acceptable as a Free Elective, subject to approval of enrollment by the teaching department offering the course. If taken within the Faculty of Applied Science and Engineering, the Free Elective must be a course carrying a weight of at least 6 units per term.

FIRST YEAR CURRICULUM--ENGINEERING

Civil Engineering	Industrial Engineering
Geological Engineering	Chemical Engineering
and Applied Earth Science	Electrical Engineering
Mechanical Engineering	Metallurgy and Materials Science

Term 1P		Lect.	Lab.	Tut.	Wt.
Computer Programming+	APS 100F/S	1	-	3	7
Engineering Graphics+	CIV 135F/S	2	5	-	8
Applied Mechanics	CIV 100F	3	-	2	10
Calculus I	MAT 186F	2	-	2	6
Algebra I	MAT 188F	2	-	2	6
Non-Technical Elective*					8

and one of:

Chemistry	CHE 111F	3	3	1	12
Chemistry	CHE 112F	3	3	1	12
Chemistry	CHE 113F	3	3	1	12

Term 1S

Computer Programming+	APS 100F/S	1	-	3	7
Engineering Graphics+	CIV 135F/S	2	5	-	8
Electricity and Magnetism	ELE 121S	3	1	1	10
Calculus II	MAT 187S	2	-	2	7
Algebra II	MAT 189S	2	-	2	6
Non-Technical Elective*					8

%and one of:

Engineering Design	CED 101S	2	1	1.5	8
Chemical Engineering Projects**	CHE 101S				8
Applied Physical Geology	GLG 180S	3	1.5	-	8
Introduction to Metals	MMS 100S	3	1.5	-	8
Introduction to Thermal Physics and Waves	PHY 182S	3	1.5	-	8

+One half of the students in Engineering will take Computer Programming in Term 1P; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

*Students will select one Non-Technical Elective course each term as described previously in this section.

%None of these Technical Electives shall be pre-requisite for any course given in a subsequent term. Any elective in which there is insufficient enrollment may be withdrawn.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7.5 hours of laboratory weekly.

FIRST YEAR CURRICULUM--ENGINEERING SCIENCE

Term 1F		Lect.	Lab.	Tut.	Wt.
Mechanics (Statics)	CIV 101F	2	-	1	6
Chemistry*	CHE 150F	3	3	1	10
Introduction to Computer Programming	CSC 180F	2	2	-	6
Calculus I	MAT 194F	3	-	2	10
Elements of Physics I (Mechanics)	PHY 180F	2	1.5	1	9
Non-Technical Elective*					8

Term 1S					
Electricity and Magnetism	ELE 150S	3	-	1	8
Linear Algebra	MAT 185S	2	-	1	8
Calculus II	MAT 195S	3	-	1	7
Elements of Physics II (Thermodynamics and Statistical Physics)	PHY 181S	2	1.5	1	9
Non-Technical Elective*					8

%and one of:					
Engineering Design	CFD 101S	2	1.5	1	8
Chemical Engineering Projects**	CHE 101S				8
Engineering Graphics	CIV 136S	2	-	2.5	8
Applied Physical Geology	GLG 180S	3	1.5	-	8
Introduction to Metals	MMS 100S	3	1.5	-	8

#Students who have not had Grade 13 Chemistry or the equivalent may petition for permission to substitute CHE 111F for CHE 150F.

*Students will select one Non-Technical Elective course each term as described previously in this section.

%None of these Technical Electives shall be pre-requisite for any course given in a subsequent term. Any elective in which there is insufficient enrollment may be withdrawn.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7.5 hours of laboratory weekly.

SECOND YEAR CIVIL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Engineering Materials	CIV 209F	4	2	1	9
Strength of Materials	CIV 210F	3	-	2	8
Surveying	CIV 255F	3	2	1	9
Computer Programming	CIV 260F	2	-	2	7
Calculus	MAT 280F	3	-	2	9
Non-Technical Elective					8

Term 2S					
Structures I	CIV 211S	4	-	2	10
Environmental Systems	CIV 240S	2	1	-	6
Civil Engineering Projects	CIV 267S	2	2	2	8
Probability and Statistics	CIV 271S	3	-	2	8
Practical Experience	APS 299Y	-	-	-	-
Geology* or	GLG 280S	2	1.5	1	8
Basic Science Course					
Economics for Engineers	ECO 281S	3	-	1	8

*Students who have taken GLG 180S in First Year must replace GLG 280S by a basic science course, normally PHY 282S. Students who have not taken GLG 180S must replace one Open, Free or Technical Elective in the Third or Fourth Years by a basic science course.

THIRD YEAR CIVIL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Structures II	CIV 312F	3	-	2	9
Soil Mechanics	CIV 321F	3	1	-	7
Transportation Systems	CIV 330F	3	-	2	8
Survey Camp*	CIV 358F	-	-	-	8
Engineering Mathematics	CIV 370F	3	-	2	8
Fluid Mechanics	MFC 351F	3	1.5	-	8
Open Elective					8

Term 3S					
Structures III	CIV 313S	3	-	2	9
Foundations	CIV 322S	2	-	2	7
Municipal and Hydraulic Engineering	CIV 340S	3	1.5	2	10
Engineering Economics and Decision Making	CIV 375S	3	-	2	8
Technical Elective**		3	-	2	8
Open Elective					8

*Survey Camp is taken prior to the commencement of regular courses in Third Year and the results included with those for the subsequent term on the basis of a weighting of 8 units.

**For list of Technical Electives, see following Fourth Year.

FOURTH YEAR CIVIL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Civil Engineering Systems	CIV 468F	3	-	2	8
Technical Elective**		3	-	2	8
Technical Elective		3	-	2	8
Technical Elective		3	-	2	8
Technical Elective		3	-	2	8
Free Elective					8

Term 4S		Lect.	Lab.	Tut.	Wt.
Public Speaking	CIV 474S	-	-	2	3
Thesis	CIV 499S	-	6	-	12
Technical Elective		3	-	2	8
Technical Elective		3	-	2	8
Technical Elective		3	-	2	8
Free Elective					8

**Technical Electives. During Third and Fourth Year, students select eight Technical Electives. Each student is advised to consult with a member of the staff in establishing the electives in his program. The Technical Electives offered by the Department of Civil Engineering are given below. Courses offered outside the department may be taken, with the approval of the Chairman of the Department.

Fall Term Electives

CIV 405F	Advanced Strength of Materials
CIV 416F	Reinforced Concrete I
CIV 419F	Indeterminate Structures
CIV 420F	Construction Engineering
CIV 421F	Foundations and Earthwork
CIV 424F	Rock Mechanics
CIV 429F	Air Photo Interpretation
CIV 430F	Traffic Engineering
CIV 431F	Transportation Planning
CIV 440F	Water and Pollution Control Engineering
CIV 450F	Water Resources and Hydrology
CIV 455F	Photogrammetry and Remote Sensing
CIV 479F	Special Studies in Civil Engineering
CIV 498F	Thesis†

†With the permission of the Chairman of the Department, a student may elect to undertake a 20-unit thesis by taking both CIV 498F and CIV 499S.

Spring Term Electives

CIV 338S	*Urban and Regional Planning Techniques
CIV 413S	*Modular Construction
CIV 414S	*Advanced Engineering Materials
CIV 417S	Reinforced Concrete II
CIV 418S	Behaviour and Design of Steel Structures
CIV 422S	*Engineering Geology
CIV 432S	Highway Engineering
CIV 441S	Air Pollution Control Engineering
CIV 456S	*Engineering Applications of Surveying
CIV 475S	Administration and Management
CIV 479S	Special Studies in Civil Engineering
MEC 452S	Hydraulic Engineering

*Available to Third and Fourth Year students.

SECOND YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

Term 2F		Lect.	Lab.	Tut.	Wt.
Strength of Materials	CIV 210F	3	-	2	8
Introductory Mineralogy and Petrology	GLG 220Y	2	3	-	9
Calculus	MAT 280F	3	-	2	9
Introduction to Mineral Engineering	MMS 224F	2	-	1	7
Economics for Engineers	ECO 281F	3	-	1	8
and one of:					
Principles of Physical Geology*	GLG 181F	2	2	1	9
Basic Classical and Modern Physics**	PHY 283F	3	-	-	8
Term 2S					
Probability and Statistics	CIV 271S	3	-	2	8
Topics in Geological Engineering	GIE 201S	2	-	2	7
Principles of Historical Geology	GLG 182S	2	2	1	9
Introductory Mineralogy and Petrology	GLG 220Y	2	3	-	9
Materials Chemistry	MMS 226S	2	-	2	8
Non-Technical Elective					8
Field Trip+	GLG 315F				
Practical Experience++	APS 299Y				

*The course is required of students who have not taken GLG 180S.

**PHY 283F is recommended preparation for PHY 338Y taken in IV year, Option A. Students who do not take PHY 283F in II year should take it as an open elective in III Year.

+Field Trip, GLG 315F, must be taken by all students in Geological Engineering and Applied Earth Science. This is an 8 day field trip immediately following term 2S examinations. Results for the camp will be included with those of the third year fall term on a basis of 6 units. A fee, currently about \$60.00, is charged to cover part of the cost of transportation and accomodation.

++Students are reminded that the practical experience requirements, see course outlines, must be completed before graduation.

THIRD YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

OPTION A (Mineral Exploration)

Term 3F		Lect.	Lab.	Tut.	Wt.
Field Trip	GLG 315F	-	-	-	6
Planning and Management of Mineral Exploration I	GLE 301F	3	-	1	8
Petrology	GLG 320Y	2	3	-	8
Stratigraphy and Sedimentation	GLG 321F	1	3	-	8
Tectonics	GIG 322Y	1	3	-	8
Phase Diagrams for Geologists	GLG 330F	3	-	-	8
Open Elective					8

Term 3S		Lect.	Lab.	Tut.	Wt.
Planning and Management of Mineral Exploration II	GLE 302S	3	-	1	8
Petrology	GLG 320Y	2	3	-	8
Tectonics	GLG 322Y	1	3	-	8
Principles of Precambrian Geology	GLG 327S	2	2	-	8
Introduction to Geochemistry	GIG 331S	3	-	-	8
Open Elective					8
Field Camp*	GLG 425F				

*Students in Option A must attend Field Camp, GLG 425F. This is a 14 day field camp immediately following Term 3S examinations. Results for the field camp will be included with those of the subsequent term on a basis of 8 units. A fee, currently about \$100.00, is charged to cover part of the cost of food and accommodation.

OPTION B (Mineral Engineering)

Term 3F		Lect.	Lab.	Tut.	Wt.
Field Trip	GLG 315F	-	-	-	6
Planning and Management of Mineral Exploration I	GLE 301F	3	-	1	8
Petrology	GLG 320Y	2	3	-	8
Mineral Processing I	MMS 301F	2	3	1	8
Minerals Equilibria	MMS 309F	3	-	2	8
Mass Transfer Operations I	CHE 310F	2	-	2	8
Open Elective					8

Term 3S		Lect.	Lab.	Tut.	Wt.
Fluid Mechanics	CHE 314S	3	1.5	1	10
Planning and Management of Mineral Exploration II	GLE 302S	3	-	1	8
Petrology	GLG 320Y	2	3	-	8
Extractive Metallurgy I	MMS 310S	3	3	1	9
Surface Properties of Materials	MMS 311S	2	-	1	7
Open Elective					8
Field Camp*	GLG 415F				

*Students in Option B must attend Field Camp GLG 415F. This is a one week field camp held immediately following Term 3S. Results for the field camp will be included with those of the subsequent term on a basis of 4 units. A fee, currently about \$60.00, is charged to cover part of the cost of food and accommodation. In addition to the one week camp, students in Option B are required to attend a one week field trip to mines and smelters. Arrangements for the trip are made by the Department of Metallurgy & Materials Science.

OPTION C, (Geotechnical Engineering)

Term 3F		Lect.	Lab.	Tut.	Wt.
Field Trip	GLG 315F	-	-	-	6
Soil Mechanics	CIV 321F	3	1	-	7
Engineering Mathematics	CIV 370F	3	-	2	8
Stratigraphy and Sedimentation	GLG 321F	1	3	-	8
Tectonics	GLG 322Y	1	3	-	8
Fluid Mechanics	MEC 351F	3	1.5	-	8
Open Elective					8
Term 3S					
Foundations	CIV 322S	2	-	2	7
Pleistocene Geology	CIV 327S	3	-	2	8
Structural Design	CIV 314S	2	-	3	8
Engineering Economics and Decision Making	CIV 375S	3	-	2	8
Tectonics	GLG 322Y	1	3	-	8
Open Elective					8
Field Camp*	GLG 416F				

*Student in Option C must attend Field Camp, GLG 416F. Results for the field camp will be included with those of the subsequent term on a basis of 8 units. This is a 14 day camp held immediately following Term 3S examinations. The first week is in the Toronto area and will include field observation and practice in geotechnical engineering. The second week is on instruction and experience in geological mapping. A fee, currently about \$60.00, is charged to cover part of the cost of food and accommodation for the second week.

FOURTH YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

OPTION A (Mineral Exploration)

Term 4F		Lect.	Lab.	Tut.	Wt.
Field Camp	GLG 425F	-	-	-	8
Economics of Mineral Resources	GLE 401F	3	-	1	8
Mineral Deposits	GLG 421Y	2	3	-	8
Exploration Geochemistry	GLG 480Y	2	3	-	8
Petroleum Geology and Energy Resources	GLG 428F	2	3	-	8
Exploration Geophysics	PHY 338Y	2	-	1	6
Geophysics Laboratory I	PHY 324H	-	3	-	4
Free Elective					8
Term 4S					
Mineral Deposits	GLG 421Y	2	3	-	8
Exploration Geochemistry	GLG 480Y	2	3	-	8
Thesis	GLE 492S	-	6	-	8
Exploration Geophysics	PHY 338Y	2	-	1	10
Geophysics Laboratory I	PHY 324H	-	3	-	4
Free Elective					8

OPTION B (Mineral Engineering)

Term 4F		Lect.	Lab.	Tut.	Wt.
Field Camp	GLG 415F	-	-	-	4
Economics of Mineral Resources	GLE 401F	3	-	1	8
Ore Mineral Identification	GLG 422Y	-	3	-	4
Hydrometallurgy	MMS 413F	2	-	1	7
Mineral Process Design	MMS 414F	2	3	-	8
Free Elective					8
and one of:					
Thesis*	GLE 493Y	-	7	-	10
Electro-Chemical					
and Kinetic Processes	MMS 302F	2	-	4	8
Extractive Metallurgy II	MMS 401F	3	1.5	1	8
Term 4S					
Ceramics	CHE 420S	2	-	1	7
Environmental Engineering	CHE 423S	2	-	1	7
Ore Mineral Identification	GLG 422Y	-	3	-	4
Metallurgical Systems Analysis	MMS 407S	2	3	1	7
Mineral Processing II	MMS 412S	2	1.5	-	7
Thesis	GLE 493	-	6	-	8
	GLE 494S	-	6	-	8
Free Elective					8

*The thesis generally extends through the Fall and Spring Terms. A shorter one-term thesis may be selected with the approval of the thesis supervisor.

OPTION C (Geotechnical Engineering)

Term 4F		Lect.	Lab.	Tut.	Wt.
Field Camp	GLG 416F	-	-	-	8
Foundations and Earthwork	CIV 421F	3	-	2	8
Rock Mechanics	CIV 424F	3	-	2	8
Subsurface Exploration	CIV 425F	3	-	2	8
Air Photo Interpretation	CIV 429F	3	2	-	8
Free Elective					8
and one of:					
Photogrammetry and Remote Sensing	CIV 455F	3	2	-	8
Construction Engineering	CIV 420F	3	-	2	8
Thesis*	GLE 495Y	-	6	-	8
Term 4S					
Engineering Geology Seminars	CIV 423S	3	-	2	8
Groundwater	CIV 449S	2	-	3	8
Design of Earth and Rock Structures	CIV 428S	2	-	3	8
Thesis	GLE 495Y	-	6	-	8
	GLE 496S	-	6	-	8
Free Elective					8
and one of:					
Environmental Systems	CIV 240S	2	1	-	6
Administration and Management	CIV 475S	3	-	2	8
Hydraulic Engineering	MFC 452S	3	2	-	8

*With the permission of the Chairman of the Division a student may elect to undertake a 16 unit thesis.

SECOND YEAR MECHANICAL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Circuit Theory and Measurements	ELE 270F	3	1.5	1.5	8
Calculus	MAT 293F	2	-	2	8
Mechanics of Solids I	MEC 211F	3	1.5	1.5	8
Differential Equations	MEC 261F	3	-	3	8
Basic Science Elective*					8
Non-technical Elective					8
Term 2S					
Electromechanical Energy Conversion	ELE 272S	2	1.5	1.5	8
Dynamics I	MFC 201S	3	-	1.5	8
Mechanics of Solids II	MEC 212S	3	-	1.5	8
Metrology	MFC 265S	2	1.5	1.5	8
Materials Science	MMS 223S	3	1.5	-	8
Economics for Engineers	ECO 281S	3	-	1	8

*A student must include a Basic Science Course in his programme.
Some acceptable courses are:

- PHY 215F Geophysics
- PHY 282F Introduction to Modern Physics
- PHY 283F Basic Classical and Modern Physics

THIRD YEAR MECHANICAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Thermodynamics I	MFC 321F	3	1.5	1.5	10
Fluid Mechanics I	MEC 341F	3	1.5	1.5	10
Engineering Analysis I	MEC 362F	3	-	3	10
Analysis and Design of Mechanisms	MEC 371F	3	-	3	10
Open Elective					8
Term 3S					
Numerical Methods	CSC 382S	2	-	1.5	8
Vibrations	MFC 303S	3	1	2	8
Thermal Energy Conversion	MFC 322S	3	3	-	8
Engineering Analysis II	MFC 363S	2	-	1.5	8
Open Elective					8
Technical Elective (one of group I)		3	1.5	1.5	8

FOURTH YEAR MECHANICAL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Mechanics of Solids III	MFC 413F	2	-	1.5	8
Heat Transfer	MFC 431F	3	1.5	1.5	8
Control Systems I	MFC 455F	3	1.5	1.5	8
Free Elective					8
Technical Elective (one of group II)		2	1.5	1.5	8
Thesis	MFC 499Y	-	-	-	8
or					
Design Project	CED 401Y	-	-	5	8
Term 4S					
Applied Fluid Mechanics	MFC 443S	3	3	-	8
Design	MFC 472S	2	-	3	8
Free Elective					8
Technical Elective (one of group I)		3	1.5	1.5	8
Technical Elective (one of group III)		2	1.5	1.5	8
Thesis	MFC 499Y	-	-	-	8
or					
Design Project	CED 401Y	-	-	5	8

Technical Electives

Group I (offered in 3S and 4S)

Thermal Environment Engineering**	MFC 324S
Analysis of Machining Processes**	MFC 375S
Analysis of Forming Processes***	MFC 376S
Biomechanical Engineering***	MFC 381S
**To be offered alternate years; available 1976/77	
***To be offered alternate years; available 1977/78	

Group II

Nuclear Engineering	CHE 477F
Instrumentation Design	ELE 471F
Dynamics II	MFC 1001F
Thermodynamics II	MFC 1101F
Fluid Mechanics II	MFC 1201F
Principles of Measurement	MFC 1050F

Group III

Direct Energy Conversion	MFC 427S
Environmental Pollution and Control	MFC 444S
Control Systems II	MFC 1303S

SECOND YEAR INDUSTRIAL ENGINEERING

		Lect.	Lab.	Tut.	Wt.
Term 2F					
Elements of Industrial Engineering I	IND 200F	2	-	2	8
Computers and Programming I	IND 202F	2	-	2	8
Calculus	MAT 293F	2	-	2	8
Probability	STA 291F	2	-	2	8
Materials Science and Engineering	MMS 222F	2	1.5	1	8
Economics for Engineers	ECO 281F	3	-	1	8
Term 2S					
Elements of Industrial Engineering II	IND 201S	2	-	2	8
Computers and Programming II	IND 203S	2	-	2	8
Calculus and Differential Equations	MAT 294S	2	-	2	8
Statistics	STA 292S	2	-	2	8
Non-Technical Elective					8
and one of:					
Mechanics of Materials	CIV 205S	2	3	-	8
Electrical Engineering	ELE 271S	3	1.5	1	8
Other Technical Elective					

THIRD YEAR INDUSTRIAL ENGINEERING

		Lect.	Lab.	Tut.	Wt.
Term 3F					
Accounting I	COM 390F	2	-	-	8
Numerical Methods I	CSC 381F	2	-	2	8
Operational Research I	IND 301F	1	-	2	8
Applied Statistical Analysis	IND 306F	2	-	2	8
Utilization of Energy	IND 308F	2	-	2	8
Open Elective*					8
Term 3S					
Operational Research II	IND 302S	2	-	2	8
Human Factors in Man-Machine Systems	IND 305S	2	3	-	8
Fundamentals of Production	IND 307S	2	-	2	8
Control Engineering	MEC 357S	2	1	1	8
Technical Elective*					
Open Elective*					8

*Electives arranged and scheduled by the Department are:

Differential Equations	APM 391F	2	-	2	8
Industrial Relations	IND 304F	2	-	1	8
Accounting II	COM 391S	2	-	-	8
Numerical Methods II	CSC 386S	2	-	2	8

The above courses qualify as Technical, Open and Free electives in Third and Fourth Years.

FOURTH YEAR INDUSTRIAL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Free Elective*					8
Thesis	IND 499Y	-	6	-	8
and four of:					
Fundamentals of Management Science	IND 413F	2	-	1.5	8
Production Systems	IND 415F	2	-	1.5	8
Scheduling and Control	IND 416F	2	-	1.5	8
Stochastic Models	IND 417F	2	-	1.5	8
System Simulation	IND 418F	2	-	1.5	8
Human Performance in Man-Machine Systems	IND 423F	2	3	-	8
Other Technical Elective*					
Term 4S					
Free Elective*					8
Thesis	IND 499Y	-	6	-	8
and four of:					
Applications of Management Science	IND 414S	2	-	1.5	8
Information and Optimization	IND 419S	2	-	1.5	8
Mathematical Programming	IND 420S	2	-	1.5	8
Management Information Systems	IND 421S	2	-	1.5	8
Human Information Processing in Man-Machine Systems	IND 424S	2	3	-	8
Dynamics of General Systems	IND 425S	2	-	1.5	8
Organizational Behaviour	IND 412S	2	1	-	8
Other Technical Elective*					

*The electives listed with the Third Year also qualify as Other Technical or Free Electives in Fourth Year.

□When Organizational Behaviour is chosen as a Technical, rather than a Free elective, then the other Technical Elective in that term is restricted to courses offered within the Faculty of Applied Science and Engineering.

Students are reminded that all their course selections in any one term, and over the entire four years, are subject to approval by the Department on their merits as a program of studies.

SECOND YEAR ENGINEERING SCIENCE

Term 2F		Lect.	Lab.	Tut.	Wt.
Differential Equations I	APM 288F	3	-	-	8
Chemical Systems	CHE 209F	3	3	-	8.5
Electric Circuits	ELE 250F	3	1.5	1	8.5
Calculus III	MAT 295F	3	-	1	8
Elements of Physics III (Fields and Waves)	PHY 280F	3	1.5	1	8
Economics for Engineers	ECO 281F	3	-	1	8
Term 2S					
Complex Variables	MAT 289S	3	-	1	8
Elements of Physics IV (Quantum Physics)	PHY 281S	2	1.5	1	8
Probability and Statistics	STA 287S	3	-	1	8
Non-Technical Elective					8
and two of:					
Engineering Design*	CFD 201S	-	-	6	8
Mechanics of Materials	CIV 203S	2	-	3	8
Computer Languages	CSC 280S	2	-	1	8
Materials Science	MMS 250S	2	1.5	-	8

*This course will be limited to 20 students.

THIRD YEAR ENGINEERING SCIENCE

Students entering Third Year may elect

- (a) to enroll in one of the 8 options listed, or
(b) to select a program that does not conform to any one of the options.

In case (a), students may petition for meritorious substitutions on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b), the weight shall average approximately 48 units per term. In both cases, the selection of courses is subject to the constraints imposed by the current timetable, and by prerequisites. Courses may be chosen from among those offered to other options in Engineering Science; from among those listed in the Faculty Calendar that are offered in programs other than Engineering Science; or, with the approval of the offering department, from among those offered in other Faculties, provided that the total applied science and engineering content is not reduced.

All electives and substitutions require the approval of the Division.

Option 5a, Aerospace

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM 388F	3	-	-	8
Mechanics	AFR 301F	3	-	1.5	8
Fluid Mechanics	AFR 305F	3	-	1.5	8
Aerospace Laboratory I	AFR 303F	-	3	-	8
Open Elective					8
and one of:					
Heat Engineering	MFC 327F	2	3	-	8
Quantum Mechanics	PHY 383F	3	-	-	8
Other Technical Elective					

Term 3S		Lect.	Lab.	Tut.	Wt.
Numerical Methods	CSC 383S	2	-	1	8
Aerospace Laboratory II	AFR 304S	-	3	-	7
Aerospace Control Systems	AFR 306S	3	-	1.5	9
Mechanics of Structures	AFR 302S	3	-	1.5	8
Technical Elective					8
Open Elective					8

Option 5c, Chemical

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM 388F	3	-	-	8
Mass Transfer Operations I	CHE 312F	2	-	2	8
Thermodynamics and Kinetics I	CHE 303F	2	3	1	10
Introductory Organic Chemistry	CHE 322F	2	3	-	8
Fluid Mechanics	MFC 354F	3	3	-	8
Open Elective					8

Term 3S

Numerical Methods	CSC 383S	2	-	1	8
Thermodynamics and Kinetics II	CHE 304S	2	3	-	9
Mass Transfer Operations II	CHE 313S	2	-	1.5	8
Chemical Engineering Problems and Laboratory	CHE 316S	-	3	2	7
Polymer Chemistry	CHE 317S	3	-	-	8
Open Elective					8

Option 5cs, Computer Science

Term 3F

Differential Equations II	APM 388F	3	-	-	8
Physical Electronics I	ELE 350F	2	.75	1	7
Electronic Circuits I	ELE 351F	2	1.5	1	8
Computer Organization	ELE 353F	3	1.5	1	10
System and Signal Analysis I	ELE 355F	3	-	1	8
Open Elective					8

Term 3S

Numerical Methods	CSC 383S	2	-	1	8
Operational Research	IND 331S	2	-	2	7
Electronic Circuits II	ELE 360S	3	1.5	-	8
Introduction to the Theory of Computation	CSC 364S	2	-	1	7
System Software I	CSC 380S	2	6	-	10
Open Elective					8

Option 5e, Electrical

Term 3F

Differential Equations II	APM 388F	3	-	-	8
Physical Electronics I	ELE 350F	2	.75	1	7
Electronic Circuits I	ELE 351F	2	1.5	1	8
System and Signal Analysis I	ELE 355F	3	-	1	8
Electromagnetic Fields	ELE 357F	3	1.5	1	9
Open Elective					8

Term 3S

Numerical Methods	CSC 383S	2	-	1	8
Physical Electronics II	ELE 352S	2	.75	1	7
Electronic Circuits II	ELE 354S	3	3	-	10
System and Signal Analysis II	ELE 356S	3	1.5	-	8
Open Elective					8

and one of:

Digital Systems	ELE 314S	2	1.5	-	6
Other Technical Elective					8

Option 5a, Geophysics

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM 388F	3	-	-	8
Principles of Physical Geology*	GLG 181F	2	2	1	9
Physics of the Earth	PHY 442Y	2	-	-	7
Electromagnetic Fields	ELE 357F	3	1.5	1	9
Open Elective					8
and one of:					
Mechanics	AER 301F	3	-	1.5	8
Electronic Circuits I	ELE 351F	2	1.5	1	8
Introductory Mineralogy and Petrology	GLG 220Y	2	3	-	9
Term 3S					
Numerical Methods	CSC 383S	2	-	1	8
Principles of Historical Geology	GLG 182S	2	2	1	9
Physics of the Earth	PHY 442Y	2	-	-	7
Elasticity and Fluid Mechanics	PHY 344S	2	-	-	8
Open Elective					8
and one of:					
Transport Phenomena	MFC 349S	3	1.5	1.5	8
Electronic Circuits II	ELE 354S	3	3	-	10
Introductory Mineralogy & Petrology	GLG 220Y	2	3	-	9

*Students with credit for GLG 180S may take two of the technical electives

Option 5m, Materials Science

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM 388F	3	-	-	8
Physical Metallurgy	MMS 303F	3	3	-	8
Metallurgical Thermodynamics	MMS 306F	2	-	4	8
Introduction to Solid State					
Physics	PHY 334F	2	-	-	8
Structure of Materials	MMS 333F	2	2	-	8
Open Elective					8
Term 3S					
Numerical Methods	CSC 383S	2	-	1	8
Physics of Metals	MMS 304S	3	3	-	8
Materials Science	MMS 307S	3	-	-	8
Metallurgical Chemistry	MMS 312S	3	-	4	9
Open Elective					8
and one of:					
Extractive Metallurgy I	MMS 305S	3	3	1	9
Surface Properties of Materials	MMS 311S	2	-	1	7
Composite Materials	CHE 413S	2	-	1	7
Other Technical Elective					8

Option 5nt, Nuclear and Thermal Power

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM 388F	3	-	-	8
Fluid Mechanics	MEC 354F	3	3	-	8
Heat Engineering	MFC 327F	2	3	-	8
Quantum Mechanics	PHY 383F	3	-	-	8
Introduction to Nuclear Physics	PHY 335F	2	-	-	8
Open Elective					8

Term 3S		Lect.	Lab.	Tut.	Wt.
Numerical Methods	CSC 383S	2	-	1	8
Statistical Thermodynamics	MFC 426S	3	1.5	-	10
Stress Analysis	MFC 315S	3	-	1	8
Nuclear Reactor Fundamentals	CHE 342S	3	1.5	-	8
Control Systems	MEC 358S	3	1.5	1	8
Open Elective					8

Option 5p, Physics

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM 388F	3	-	-	8
Mechanics	AFR 301F	3	-	1.5	8
Electromagnetic Fields	ELE 357F	3	1.5	1	9
Quantum Mechanics	PHY 383F	3	-	-	8
Open Elective					8

and one of:

Physical Electronics I	ELE 350F	2	.75	1	7
Introduction to Solid State Physics	PHY 334F	2	-	-	8
Introduction to Nuclear Physics	PHY 335F	2	-	-	8

Term 3S		Lect.	Lab.	Tut.	Wt.
Numerical Methods	CSC 383S	2	-	1	8
Statistical Thermodynamics	MEC 426S	3	1.5	-	10
Modern Physics Laboratory	PHY 326S	-	6	-	8
Open Elective					8

and two of:

Physical Electronics II	ELE 352S	2	.75	1	7
Nuclear Reactor Fundamentals	CHE 342S	3	1.5	-	8
Radiobiology	PHY 359S	2	-	-	8
Elementary Particle Physics	PHY 337S	2	-	-	8

FOURTH YEAR ENGINEERING SCIENCE

Option 5a, Aerospace

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	ESC 495Y	-	-	-	8
Applied Functional Analysis	APM 446F	3	-	-	8
Free Elective					8
and one of:					
Engineering Design I	AER 406F	-	3	-	8
Aerospace Laboratory III	AFR 408F	-	6	-	8
and two of:					
Aerodynamics	AFR 401F	3	-	1.5	9
Advanced Mechanics of Structures	AFR 403F	2	-	1.5	8
Fundamentals of Lasers, Plasmas and Energy	AFR 415F	3	-	1.5	9
Term 4S					
Thesis	ESC 495Y	-	-	-	8
Mathematical or Theoretical Elective °					8
Free Elective					8
and one of:					
Engineering Design II	AER 407S	-	3	-	7
Aerospace Laboratory IV	AER 409S	-	6	-	7
and two of:					
Gasdynamics	AFR 410S	3	-	1.5	9
Stability and Control of Aircraft	AFR 411S	3	-	1.5	9
Aeroelasticity	AER 412S	2	-	1.5	8
Acoustic Theory and Noise Control	AFR 414S	2	1.5	-	8
Other Technical Elective					8

°Acceptable courses are listed below. Consult Divisional Office for descriptions and timetable information.

1. Optimization and Control Theory	APM 456S	2	-	1	8
2. Fluid Mechanics (except 5a)	APM 436S	3	-	-	8
3. Techniques of Optimization	ELE 455S	3	-	1	8
4. Applied Algebra	CSC 478S	2	-	1	8
5. Computational Methods for Partial Differential Equations	CSC 446S	2	-	1	8
6. Probability and Applications	STA 347S	3	-	-	8
7. Classical Mechanics (except 5a,5p)	PHY 351S	3	-	-	8
8. Topics in Applied Mathematics	AER 1016S	2	-	-	8
9. Engineering Analysis IV	MFC 1402S	2	-	-	8
10. Applied Mathematics for Chemical Engineers	CHE 1107S	2	-	1	8

Option 5c, Chemical

		Lect.	Lab.	Tut.	Wt.
Term 4F					
Thesis	ESC 495Y	-	-	-	8
Applied Functional Analysis	APM 446F	3	-	-	8
Rate Processes I	CHE 435F	3	-	-	9
Free Elective					8
and two of:					
Chemical Plant Design	CHE 406F	-	-	6	9
Chemical Engineering Thermodynamics	CHE 402F	2	-	1	7
Advanced Separation Processes	CHE 410F	2	-	1	7
Economic Evaluation in the Process Industries	CHE 456F	2	-	1	7
Strategy of Product and Process Development	CHE 409F	2	3	-	9
Optimal Control of Chemical Systems	CHE 437F	3	-	1.5	9
Other Technical Elective					8

Term 4S					
Thesis	ESC 495Y	-	-	-	8
Mathematical or Theoretical Elective °					8
Rate Processes II	CHE 436S	3	-	-	8
Free Elective					8
and two of:					
Environmental Engineering	CHE 423S	2	-	1	7
Plastics Engineering	CHE 444S	2	-	1	7
Electrochemistry and Corrosion	CHE 453S	2	-	1	7
Selected Topics in Organic Chemistry	CHE 434S	2	-	1	7
Modelling and Simulation of Chemical Systems	CHE 440S	3	-	-	9
Chemical Reactors	CHE 432S	2	-	1	7
Other Technical Elective					8

Option 5cs, Computer Science

Term 4F					
Thesis	ESC 498F	-	-	-	8
Applied Functional Analysis	APM 446F	3	-	-	8
Switching Theory	ELE 405F	2	-	2	8
Communication Systems I	ELE 453F	2	3	-	8
Operating Systems	CSC 468F	2	-	1	8
Free Elective					8

Term 4S					
Mathematical or Theoretical Elective °					8
System Software II	CSC 480S	2	6	-	10
Switching Circuits	ELE 432S	2	3	-	8
Free Elective					8
and two of:					
Techniques of Optimization	ELE 455S	3	-	1	8
Computational Methods for Partial Differential Equations	CSC 446S	2	-	1	8
Architecture of Distributed Computer Systems	CSC 458S	2	-	1	8
Applied Algebra	CSC 478S	2	-	1	8
Communication Systems II	ELE 454S	2	3	-	8

°Acceptable courses are listed under the program of option 5a. Consult Divisional Office for descriptions and timetable information.

Option 5e, Electrical

Term 4F		Lect.	Lab.	Tut.	Wt.
Applied Functional Analysis	APM 446F	3	-	-	8
Free Elective					8
Select courses from the following to total approximately 48 units for the term:*					
Computer Organization	ELE 353F	3	1.5	1	10
Network Theory	ELE 412F	3	-	2	8
Semiconductor Electronics	ELE 435F	2	1.5	1	8
Computer Software Engineering I	ELE 440F	2	-	2	8
Electromagnetics	ELE 420F	2	1	1	8
Electronic Circuits III	ELE 452F	2	3	-	8
Communication Systems I	ELE 453F	2	3	-	8
Switching Theory	ELE 405F	2	-	2	8
Fundamentals of Lasers, Plasmas and Energy	AER 415F	3	-	1.5	9
Power Semiconductor Circuits	ELE 433F	2	3	-	8
Thesis ¹	ESC 495Y	-	-	-	8
Other Technical Elective					8

Term 4S					
Mathematical or Theoretical Elective ⁰					8
Free Elective					8
Thesis ¹	ESC 495Y	-	-	-	8
Thesis ¹	ESC 498S	-	-	-	8
Select courses from the following to total approximately 48 units for the term, at least 16 units of which must be from Electrical Engineering:*					
Nuclear Reactors and Instruments	CHE 429S	2	1.5	1	8
Operational Research	IND 331S	2	-	2	7
Integrated Circuits	ELE 431S	2	3	-	8
Switching Circuits ²	ELE 432S	2	3	-	8
Techniques of Optimization	EIE 455S	3	-	1	8
Computer Organization	ELE 441S	2	3	-	8
Biomedical Engineering ²	ELE 445S	3	1.5	-	8
Communication Systems II	ELE 454S	2	3	-	8
High-Frequency Active Devices	ELE 423S	2	1.5	1	8
Other Technical Elective					8

⁰Acceptable courses are listed under the program of option 5a. Consult Divisional Office for descriptions and timetable information.

*Courses for which there is insufficient demand may be withdrawn.

¹Select either ESC 495Y or ESC 498S, but not both.

²Limited enrollment

Note: the following is a partial list of other technical electives suitable for option 5e:

ELE 413F Power Systems Analysis
 ELE 448F Applied Optics
 ELE 411S Control Systems II
 ELE 419S Electromechanical Systems III
 ELE 422S Radio Systems
 ELE 442S Computer Software Engineering II

Option 5g, Geophysics

Term 4P		Lect.	Lab.	Tut.	Wt.
Applied Functional Analysis	APM 446F	3	-	-	8
Theory and Application of Geophysical Methods	PHY 443Y	2	-	-	6
Geophysics Laboratory	PHY 388F	-	3	-	5
Time Series Analysis Laboratory	PHY 422F	-	6	-	8
Thesis	FSC 499Y	-	-	-	5
Technical Elective*					8
Free Elective					8
Term 4S					
Mathematical or Theoretical Elective °					8
Theory and Application of Geophysical Methods	PHY 443Y	2	-	-	6
Geophysics Laboratory	PHY 389S	-	3	-	5
Thesis	ESC 499Y	-	-	-	5
Technical Elective 1*					8
Technical Elective 2*					8
Free Elective					8

*At least one of the three Technical Electives must be a course offered by a Department of the Faculty of Applied Science and Engineering or by the Department of Geology. A list of recommended options is available from the Engineering Science Division Office or the Geophysics Laboratory.

°Acceptable courses are listed under the program of option 5a. Consult Divisional Office for descriptions and timetable information.

Option 5m, Materials Science

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	ESC 495Y	-	-	-	8
Applied Functional Analysis	APM 446F	3	-	-	8
Solid State Science	MMS 402F	3	1.5	1	8
Theory of Metallurgical Reactions	MMS 410F	2	-	2	8
Free Elective					8
and one of:					
Extractive Metallurgy II	MMS 401F	3	1.5	1	8
Materials Engineering I	MMS 432F	3	1.5	1	8
Polymer Engineering	CHE 415F	2	-	1	7
Introduction to Nuclear Engineering	CHE 427F	2	-	1	7
Other Technical Elective					8

Term 4S					
Thesis	ESC 495Y	-	-	-	8
Mathematical or Theoretical Elective ^o					8
Advanced Materials Science	MMS 411S	3	1.5	-	7
Advanced Chemical Metallurgy	MMS 406S	2	-	2	8
Free Elective					8
and one of:					
Materials Engineering II	MMS 408S	3	-	1	8
Plastics Engineering	CHE 444S	2	-	1	7
Nuclear Materials	MMS 416S	2	-	1	7
Advanced Iron & Steelmaking	ESC 420S	3	-	-	7
Other Technical Elective					8

Option 5nt, Nuclear and Thermal Power

Term 4F					
Thesis	ESC 495Y	-	-	-	8
Applied Functional Analysis	APM 446F	3	-	-	8
Nuclear Systems Analysis	CHE 452F	2	1.5	1	8
Energy Conversion	MFC 428F	3	1.5	-	8
Free Elective					8
and one of:					
Electronic Circuits I	ELE 351F	2	1.5	1	8
Introduction to Solid State Physics	PHY 334F	2	-	-	8
Nuclear Physics I ⁺	PHY 486F	2	-	-	8

Term 4S					
Thesis	ESC 495Y	-	-	-	8
Mathematical or Theoretical Elective ^o					8
Heat Transfer	MFC 433S	2	-	2	8
Free Elective					8
and two of:					
Electronic Circuits II	ELE 360S	3	1.5	-	8
Nuclear Materials	MMS 416S	2	-	1	7
Nuclear Physics II ⁺	PHY 487S	2	-	-	8
Radiobiology	PHY 359S	2	-	-	8
Other technical Elective					8

^oAcceptable courses are listed under program 5a. Consult Divisional Office for descriptions and timetable information.

⁺Sequential courses. Both I and II should be taken.

Options 5p, Physics

Term 4P		Lect.	Lab.	Tut.	Wt.
Applied Functional Analysis	APM 446F	3	-	-	8
Technical Elective *					8
Free Elective					8
and three of:					
Quantum Physics Laboratory	PHY 426F	-	6	-	8
Quantum Theory I ⁺	PHY 482F	2	1	-	8
Statistical Mechanics I ⁺	PHY 484F	2	1	-	8
Relativity Theory I ⁺	PHY 452Y	2	1	-	8
Nuclear Physics I ⁺	PHY 486F	2	1	-	8
High Energy Physics I ⁺	PHY 488F	2	1	-	8
Solid State Physics I ⁺	PHY 490F	2	1	-	8
Modern Optics and Radiation I ⁺	PHY 492F	2	1	-	8
Group Theory and its Physical Applications I ⁺	PHY 494F	2	1	-	8
Term 4S**					
Thesis	ESC 498S	-	-	-	8
Technical Elective 1*					8
Technical Elective 2*					8
and choose 3 courses from the following, at least 1 from Group A:					
Group A					
Quantum Theory II ⁺	PHY 483S	2	-	-	8
Statistical Mechanics II ⁺	PHY 485S	2	1	-	8
Relativity Theory	PHY 452Y	2	1	-	8
Mathematical or Theoretical Elective ^o					8
Group B					
Quantum Physics Laboratory II ⁺	PHY 429S	-	6	-	8
Nuclear Physics II ⁺	PHY 487S	2	1	-	8
High Energy Physics II ⁺	PHY 489S	2	1	-	8
Solid State Physics II ⁺	PHY 491S	2	1	-	8
Modern Optics and Radiation II ⁺	PHY 493S	2	1	-	8
Group Theory and its Physical Applications II ⁺	PHY 495S	2	1	-	8

*These Technical Electives must all be courses offered by a department of the Faculty of Applied Science and Engineering.

**If the Free Elective chosen in the Fall Term is a Full year course, the portion offered in the Spring Term may be used to replace one of the Spring Term Electives.

^oAcceptable courses are listed under the program of option 5a. Consult Divisional Office for descriptions and timetable information.

⁺Sequential courses. Both I and II should be taken.

SECOND YEAR CHEMICAL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Physicochemical Principles in					
Chemical Engineering I	CHE 201F	2	-	-	5
Analytical Chemistry	CHE 204F	2	10.5	-	14
Industrial Process Operations I	CHE 205F	3	-	2	9
Inorganic Chemistry I	CHE 217F	2	-	-	5
Calculus	MAT 280F	3	-	2	9
Non-Technical Elective					8

Term 2S

Physicochemical Principles in					
Chemical Engineering II	CHE 202S	2	3	-	8
Industrial Process Operations II	CHE 206S	3	6	2	13
Organic Chemistry I	CHE 207S	3	3	-	10
Applied Mathematics in Chemical Eng. I	CHE 210S	2	-	1	6
Inorganic Chemistry II	CHE 218S	2	-	-	5
Economics for Engineers	ECO 281S	3	-	1	8

All students must complete Practical Experience APS 299 during their undergraduate program. This is normally satisfied during the summer periods between the Second and Third, or Third and Fourth Years.

THIRD YEAR CHEMICAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Thermodynamics and Kinetics I	CHE 301F	3	6	2	14
Applied Mathematics in Chemical Eng. II ¹	CHE 321F	2	-	1	6
Organic Chemistry II	CHE 309F	3	9	-	14
Mass Transfer Operations I	CHE 310F	2	-	2	8
Open Elective					8

Term 3S

Thermodynamics and Kinetics II	CHE 302S	3	6	2	14
Mass Transfer Operations II	CHE 311S	2	4.5	1	11
Fluid Mechanics	CHE 314S	3	1.5	1	10
Chemical Engineering Topics I	CHE 320S	3	-	-	6
Open Elective					8

All students must take a one-term science course in either the Third or Fourth Year. Normally this course is selected from courses offered by the Department of Chemistry, Physics, Biochemistry, Mathematics, Biology, Geology or Geography in the Faculty of Arts and Science; courses offered in other departments may also be acceptable. In Third Year the science course can be selected as an Open Elective.

Students are reminded of the necessity to complete the Practical Experience, APS 299.

FOURTH YEAR CHEMICAL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis and Dissertation	CHE 499Y	-	8	2	10
Chemical Engineering Topics II	CHE 401F	3	-	-	7
Free Elective					8
three of:*					
Chemical Engineering Thermodynamics	CHE 402F	2	-	1	7
Energy, Environment and Resources	CHE 454F	2	-	1	7
Topics in Heat Transfer	CHE 455F	2	-	1	7
**Pulp and Paper Chemistry, Technology and Engineering	CHE 417F	2	-	1	7
Industrial Biological Processes	CHE 448F	2	-	1	7
Economic Evaluation in the Process Industries	CHE 456F	2	-	1	7
Chemical Plant Design	CHE 405F	-	-	6	7
Process Modelling and Simulation	CHE 407F	2	-	3	7
Strategy of Product and Process Development	CHE 408F	2	3	-	7
Advanced Separation Processes	CHE 410F	2	-	1	7
**Atmospheric Dispersion	CHE 446F	2	-	1	7
Pipeline Transportation	CHE 412F	2	-	1	7
Introduction to Nuclear Engineering	CHE 427F	2	-	1	7
Polymer Engineering	CHE 415F	2	-	1	7
**Topics in Applied Chemical Thermodynamics	CHE 404F	2	-	1	7
Ceramics	CHE 420F	2	-	1	7
Catalysis	CHE 447F	2	-	1	7
Hydrometallurgy	MMS 413F	2	-	1	7
Term 4S					
Thesis and Dissertation	CHE 499Y	-	12	3	17
Public Speaking	CHE 498S	-	-	2	4
Free Elective					8
three of:*					
Chemical Reactors	CHE 432S	2	-	1	7
Applied Nuclear Chemistry	CHE 418S	2	-	1	7
Environmental Engineering	CHE 423S	2	-	1	7
Instrumental Methods	CHE 425S	2	-	1	7
Advanced Inorganic Chemistry	CHE 426S	2	-	1	7
Optimal Control	CHE 431S	2	-	1	7
Electrochemical Energy	CHE 453S	2	-	1	7
Selected Topics in Organic Chemistry	CHE 434S	2	-	1	7
Plastics Engineering	CHE 444S	2	-	1	7
Petroleum Engineering	CHE 445S	2	-	1	7
Composite Materials	CHE 413S	2	-	1	7
Nuclear Chemical Engineering	CHE 449S	2	-	1	7
Innovation and Entrepreneurship for Chemical Engineers	CHE 457S	2	-	1	7
Chemical Engineering in Medicine	CHE 458S	2	-	1	7
Physical Chemistry of Iron and Steelmaking	MMS 421S	2	-	1	7
Other Technical Elective					7

Students are reminded that they must take a one-term basic science course before graduation. If this requirement has not been satisfied in the Third Year, then a science course may be selected as either a Technical Elective or a Free Elective in the Fourth Year. *Any elective for which too few students register may be withdrawn. **Not offered in 1976-77

SECOND YEAR ELECTRICAL ENGINEERING

		Lect.	Lab.	Tut.	Wt.
Term 2F					
Differential Equations	MAT 290F	3	-	2	8
Complex Variable and Vector Calculus	ELE 200F	3	-	2	8
Circuit Theory I	ELE 210F	4	1.5	1	11
Materials Science I	MMS 221F	3	1.5	-	8
Dynamics	MFC 205F	2	-	1	6
Economics for Engineers	ECO 281F	3	-	1	8
Term 2S					
Numerical Methods	ELE 201S	2	-	2	6
Electric and Magnetic Fields	ELE 221S	3	-	2	8
Circuit Theory II	ELE 211S	3	1.5	1	9
Materials Science II	MMS 227S	2	1.5	-	7
Electronic Circuits A	ELE 231S	3	1.5	1	10
Non-Technical Elective					8

THIRD YEAR ELECTRICAL ENGINEERING

		Lect.	Lab.	Tut.	Wt.
Term 3F					
Electromechanical Systems I	ELE 312F	3	1.5	1	9
Systems and Signal Analysis A	ELE 310F	3	-	2	9
Physical Electronics A	ELE 335F	2	.75	.75	6
Fields and Waves	ELE 320F	2	1.5	1	8
Thermodynamics and Statistical Mechanics	PHY 384F	3	-	1	8
Open Elective					8
Term 3S					
Digital Systems	ELE 314S	2	1.5	-	6
Electromechanical Systems II	ELE 313S	3	1.5	1	9
System and Signal Analysis B	ELE 311S	3	1.5	1	9
Physical Electronics B	ELE 336S	2	-	1.5	6
Electronic Circuits B	ELE 331S	3	3	-	10
Open Elective					8

FOURTH YEAR ELECTRICAL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Free Elective					8
Select additional courses from the following to total 48 units ² for the term including at least 32 units from Group A.*					
Group A					
Thesis ⁴	ELE 498F	-	-	-	8
Thesis ⁴	ELE 496F	-	-	-	16
Communication Systems A	ELE 416F	2	3	-	8
Switching Theory	ELE 405F	2	-	2	8
Electromagnetics	ELE 420F	2	1	1	8
Control Systems I	ELE 410F	2	1.5	1	8
Power Semiconductor Circuits ⁵	ELE 433F	2	3	-	8
Applied Optics	ELE 448F	2	1.5	1	8
Electronic Circuits C	ELE 430F	2	3	-	8
Computer Software Engineering I	ELE 440F	2	-	2	8
Semiconductor Electronics	ELE 435F	2	1.5	1	8
Power System Analysis ⁵	ELE 413F	2	1.5	1	8
Network Theory	ELE 412F	3	-	2	8
Group B					
Engineering as a Profession ⁵	ELE 449F	2	-	-	8
Other Technical Elective ³		-	-	-	8

¹Courses joined by arrows cannot be taken together because of timetable conflicts.

²For students proceeding at a normal rate.

³Any Third or Fourth Year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrollments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

⁴A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

⁵Limited enrollment.

*Departmental electives for which there is insufficient demand may be withdrawn.

FOURTH YEAR ELECTRICAL ENGINEERING (CONTINUED)

Term 4S		Lect.	Lab.	Tut.	Wt.
Free Elective					8
Select additional courses from the following to total 48 units ² including at least 32 units from Group A.*					
Group A					
Thesis*	ELE 499S	-	-	-	8
Thesis*	ELE 497S	-	-	-	16
Control Systems II	ELE 411S	2	1.5	1	8
Computer Organization	ELE 441S	2	3	-	8
Electromechanical Systems III	ELE 419S	2	1.5	1	8
Communication Systems II	ELE 454S	2	3	-	8
Biomedical Engineering ⁵	ELE 445S	3	1.5	-	8
Illumination ⁵	ELE 447S	3	1.5	-	8
High Frequency Active Devices	ELE 423S	2	1.5	1	8
Power System Control ⁵	ELE 414S	2	1.5	1	8
Radio Systems	ELE 422S	2	-	1	8
Switching Circuits	ELE 432S	2	3	-	8
Integrated Circuits	ELE 431S	2	3	-	8
Computer Software Engineering II	ELE 442S	3	1.5	-	8
Group B					
Nuclear Reactors and Instruments	CHE 429S	2	1.5	1	8
Acoustic Theory and Noise Control	AER 414S	2	1.5	-	8
Organizational Behaviour	IND 426S	2	1	-	8
Other Technical Elective ³		-	-	-	8

¹Courses joined by arrows cannot be taken together because of timetable conflicts.

²For students proceeding at a normal rate.

³Any Third or Fourth Year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrollments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

*A thesis is compulsory. The minimum weighting is 8 for the year. The maximum permitted is 16 for the year. Thus the selections allowed are any one of ELE 496F, 497S, 498F or 499S; or both of ELE 498F and ELE 499S. The selection must be approved by the student's thesis supervisor.

⁵Limited enrollment.

*Departmental electives for which there is insufficient demand may be withdrawn.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

Term 2F		Lect.	Lab.	Tut.	Wt.
Calculus	MAT 293F	2	-	2	8
Introduction to Modern Physics	PHY 282F	3	-	-	8
Mechanics of Materials	CIV 204F	3	1.5	-	8
Structure of Materials and Metallography	MMS 201F	2	3	1	8
Metallurgical Thermodynamics I	MMS 202F	2	-	3	8
Non-Technical Elective					8
Term 2S		Lect.	Lab.	Tut.	Wt.
Calculus and Differential Equations	MAT 294S	2	-	2	8
Probability and Statistics	STA 282S	2	-	2	8
Metallurgical Thermodynamics II	MMS 203S	2	-	3	8
Materials Chemistry	MMS 204S	2	3	2	9
Materials Science	MMS 205S	2	-	2	7
Economics for Engineers	ECO 281S	3	-	1	8
Practical Experience	APS 299Y	-	-	-	-

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations	APM 391F	2	-	2	8
Mineral Processing I	MMS 301F	2	3	1	8
Electrochemical and Kinetic Processes	MMS 302F	2	-	4	8
Physical Metallurgy	MMS 303F	3	3	-	8
Ceramic Materials	MMS 308F	2	-	2	8
Open Elective					8
Term 3S		Lect.	Lab.	Tut.	Wt.
Numerical Methods	CSC 382S	2	-	1.5	8
Transport Phenomena	MEC 349S	3	1.5	1.5	8
Physics of Metals	MMS 304S	3	3	-	8
Extractive Metallurgy I	MMS 305S	3	3	1	9
Surface Properties of Materials	MMS 311S	2	-	1	7
Open Elective					8

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

Term 4F		Lect.	Lab.	Tut.	Wt.
Electrical Systems	ELE 470F	3	3	-	9
Extractive Metallurgy II	MMS 401F	3	1.5	1	8
Materials Engineering I	MMS 432F	3	1.5	1	8
Thesis	MMS 499Y	-	6	-	6
Free Elective					8
and one of: (1) (2)					
Mineral Process Design	MMS 414F	2	3	-	8
Solid State Science	MMS 402F	3	1.5	1	8
Term 4S					
Advanced Chemical Metallurgy	MMS 406S	2	-	2	8
Materials Engineering II	MMS 408S	3	-	-	8
Thesis	MMS 499	-	12	-	12
Free Elective					8
one of: (2)					
Metallurgical Systems Analysis	MMS 407S	2	3	1	7
Mineral Processing II	MMS 412S	2	1.5	-	7
Advanced Iron and Steel Making	MMS 420S	3	-	-	7
and one of: (2)					
Advanced Materials Science	MMS 411S	3	1.5	-	7
Applied Physical Metallurgy	MMS 417S	3	-	1	7
Composite Materials	CHE 413S	2	-	1	7

¹With the approval of the Chairman of the Department, any other suitable technical course may be substituted as an elective.

²The student must consult with his assigned staff tutor before choosing Technical Electives. Departmental electives for which there is insufficient demand may be withdrawn.

Course Outlines

On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes (AER, CIV, etc.) which identify the teaching department. The suffix following the course number indicates the term in which the course is given; the second line of the description shows the program† and year in which the course is prescribed, and the number of hours of lectures, laboratory and tutorial work per week, and the weight units assigned to the course. For example:

CHE 423S ENVIRONMENTAL ENGINEERING
IV-2B; IV-6,5c (elective)

2 - 1 7

indicates a spring-term course offered by the Department of Chemical Engineering. It is a compulsory course for students in Fourth Year Geological Engineering, Option B, and is an elective course for students in Fourth Year Chemical Engineering and Fourth Year Engineering Science, Option C. The course consists of 2 hours lectures, no laboratory, and 1 hours tutorial per week, and has a weight of seven units.

Many course descriptions include a statement of exclusions, prerequisites and corequisites for the information of students, but the absence of such a statement does not imply that the course does not have such conditions. In these statements, the solidus symbol (/) means OR, and the comma (,) means AND.

The recommendations for textbooks should be considered as tentative only, and subject to change. Students should therefore not purchase textbooks until they have been in attendance in the course, unless informed otherwise by their department.

Interpretation of suffixes to course numbers:

F: A first-term (Fall) course.

S: A second-term (Spring) course.

F/S: Indicates that the course given in the first term is repeated in the second term; a student may take one or the other, but not both.

Y: A course which continues over both terms.

In some courses offered by the Faculty of Arts and Science, suffixes A,B and H are also used to distinguish Fall Term, Spring Term and full year courses respectively.

†Program codes:

- | | |
|---------------------------|--|
| 1. Civil Engineering | 5. Engineering Science |
| 2. Geological Engineering | 6. Chemical Engineering |
| 3. Mechanical Engineering | 7. Electrical Engineering |
| 4. Industrial Engineering | 8. Metallurgy and Materials
Science |

AEROSPACE SCIENCE AND ENGINEERING

AER 301F MECHANICS

III-5a,5g,5p

3 - 1.5 8

Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Special topics by request. Primary Reference: class notes. Reference Books: Greenwood, Principles of Dynamics; Page, Introduction to Theoretical Physics, Principles of Mechanics.

P.A. Sullivan

AER 302S MECHANICS OF STRUCTURES

III-5a

3 - 1.5 8

Basic theorems and principles in the theory of structures (strain energy, virtual displacements, minimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multi-flanged beams, open and closed sections). General theory of torsion (thin walled structures, multicell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions). Application of theory to the design of aerospace structures is given in tutorials.

R.C. Tennyson

AER 303F AEROSPACE LABORATORY I

III-5a

- 3 - 8

Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER 304S AEROSPACE LABORATORY II

III-5a

- 3 - 7

Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER 305F FLUID MECHANICS

III-5a

3 - 1.5 8

The physical concepts of fluid flow are developed along with the mathematics and illustrated via examples. Major topics are: introductory concepts and idealizations of real fluids; conservation equations (mass, momentum) for inviscid fluids; Bernoulli's equation; coordinate systems; boundary conditions; vorticity and vortex theorems; potential flow; 3D sources, sinks, doublets, modelling of flow about "half body" and sphere; complex potential and corresponding 2D flows; conformal transformations; mapping of sphere into other shapes; viscous flow; Navier-Stokes equations; Couette and Poiseuille flows; introduction to boundary layer theory. Reference Books: Prandtl and Tietjens, Fundamentals of Hydro and Aeromechanics; Streeter, Fluid Dynamics (1948 ed. only!); Lamb, Hydrodynamics.

H.S. Ribner

AER 306S AEROSPACE CONTROL SYSTEMS

III-5a

3 - 1.5 8

Mathematical representation of linear dynamic systems. Response of linear dynamic systems. Stability. Introduction of feedback, and system response. Root locus concepts. Nyquist plot. Frequency response. Identification of system variables, feedback possibilities, and sensing elements for aerospace systems. Control of aircraft. Control of launch vehicles. Spacecraft attitude control. References: Dynamics and Automatic Control (D. McRuer, I. Ashkenas, D. Graham; Princeton Univ. Press); Analysis and Design of Space Vehicle Flight Control Systems (A.L. Greensite: Spartan).

P.C. Hughes

AER 401F AERODYNAMICS

IV-5a (elective)

3 - 1.5 9

Thin airfoil theory, vortex theory, finite wings, compressibility effects, supersonic and hypersonic wing theory. Propulsion: momentum theorem, propeller actuator disc analysis, blade element approach, axial compressors and turbines. Air cushion vehicles. Aircraft performance; drag, basic performance parameters, range, turning flight take-off. Illustrative design methodology. Basic concepts in static stability and control. Reference Books: Kuethé and Schetzer, Foundations of Aerodynamics; McCormick, Aerodynamics of V/STOL Flight.

L.D. Reid

AER 403F ADVANCED MECHANICS OF STRUCTURES

IV-5a (elective)

2 - 1.5 8

Matrix analysis of redundant structures including the force and displacement methods. Flexibility and stiffness matrices for structural elements derived, effects of thermal strains and structural cutouts. Automated techniques for determining redundant members. The finite element approach, derived, and applied to plates and shells. The method of individual displacements, with solutions given for buckling loads, natural frequencies and stress distributions in structures. Application of analytical methods to the design of aerospace structures is given in tutorials. Reference Books: J.S. Przemienicki, Theory of Matrix Structural Analysis, McGraw-Hill, New York (1968); Zienkiewicz, O.C. and Cheung, Y.K., The Finite Element Method in Structural and Continuum Mechanics, McGraw-Hill, London (1967).

R.C. Tennyson, J.S. Hansen

AER 406F ENGINEERING DESIGN I

IV-5a (elective)

- 3 - 8

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required.

G.W. Johnston

AER 407S ENGINEERING DESIGN II

IV-5a (elective)

- 3 - 7

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required.

J.W. Locke

AER 408F AEROSPACE LABORATORY III

IV-5a (elective)

- 6 - 8

Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER 409S AEROSPACE LABORATORY IV

IV-5a (elective)

- 6 - 7

Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of materials in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER 410S GASDYNAMICS

IV-5a (elective)

3 - 1.5 9

Fundamental phenomena occurring in compressible flows are treated. Basic thermodynamics and the equations of inviscid and viscous compressible flows are reviewed. Compressible flows in nozzles, diffusers, and ducts with viscous and diabatic effects, and shock and expansion waves in both steady and nonstationary flows including high temperature effects that cause departures from the perfect gas law and equilibrium, are discussed. The lectures are illustrated by a set of synthesizing analytic and engineering problems in a tutorial laboratory. Reference Books: Liepmann and Roshko, Elements of Gasdynamics; Shapiro, Dynamics and Thermodynamics of Compressible Fluid Flow; Glass, Shock Waves and Man. (Prerequisite: AER 305F).

I.I. Glass

AER 411S STABILITY AND CONTROL OF AIRCRAFT

IV-5a (elective)

3 - 1.5 9

Introduction to the dynamic stability and control-response of aircraft. Equations of motion for small perturbations from steady flight: longitudinal stability; lateral stability; response to throttle, elevator, aileron, rudder; flight in turbulence. Reference Book: Etkin, Dynamics of Flight-Stability and Control. (Prerequisite: AER 401F)

J.D. DeLaurier

AER 412S AEROELASTICITY

IV-5a (elective)

2 - 1.5 8

Static aeroelastic phenomena are studied, including divergence of slender wings, the effect of low aspect ratio, sweep and wing-aileron interaction. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed. Reference Books: Fung, Y.C., An Introduction to the Theory of Aeroelasticity, Dover Paperback Publications (1969).

J.D. DeLaurier

AER 414S ACOUSTIC THEORY AND NOISE CONTROL

IV-3,5a, 7 (elective)

2 1.5 - 8

Basic acoustic theory including acoustic plane waves in infinite medium, real fluid effects, radiation of sound in three dimensions, sound propagation in ducts, and architectural acoustics. Noise control theory including transmission and radiation of sound by solid structures, mufflers, filters, resonators, enclosures and porous lining, sound propagation outdoors, subjective response to noise and industrial sources.

H.S. Ribner, G.W. Johnston

AER 415P FUNDAMENTALS OF LASERS, PLASMAS AND ENERGY

IV-5a,5e (elective)

3 - 1.5 9

Energy and its interrelation with society, including forms of energy, sources of energy, flow patterns, demand and reserves, energy conversion, storage and transmission, energy and the environment. Introduction to a plasma, review of Maxwell's equations, motion of charged particles, magnetic confinement of a plasma, plasma equations, review of atomic physics and quantum concepts, radiation from plasmas, plasma spectroscopy, controlled thermonuclear fusion. Introduction to laser physics and review of their properties with particular emphasis on how they are used to both diagnose and create plasmas.

R.M. Measures

APPLIED MATHEMATICS
(Department of Mathematics)

APM 288F DIFFERENTIAL EQUATIONS I
II-5

3 - - 8

Ordinary differential equations. Existence and uniqueness theorems. General theory of linear homogeneous systems. Asymptotic behaviour and stability. Linear non-homogeneous systems. Series solution of linear equations with analytic coefficients, Bessel and Legendre equations. Boundary value problems. Sturm-Liouville systems. Green's functions. Eigenvalue problems. Stability of non-linear plane autonomous systems.

APM 388F DIFFERENTIAL EQUATIONS II
III-5

3 - - 8

Classification of linear partial differential equations of second order, hyperbolic, parabolic and elliptic equations, initial value problems, the method of characteristics, boundary value problems, separation of variables, eigenfunction expansions, Fourier transforms, Green's functions, cylindrical and spherical functions with applications.

APM 391F DIFFERENTIAL EQUATIONS
III-8; III-4 (elective)

2 - 2 8

First and second order ordinary differential equations, operational methods, variation of parameters, solution in series. Bessel and Legendre functions, the Laplace transform. (Prerequisite: MAT 294S)

APM 446F APPLIED FUNCTIONAL ANALYSIS
IV-5

3 - - 8

Fredholm and Volterra integral equations, applications to boundary value problems and partial differential equations, variational methods, nonlinear integral equations.

APPLIED SCIENCE AND ENGINEERING-INTERDEPARTMENTAL

APS 100F/S COMPUTER PROGRAMMING

I-1,2,3,4,6,7,8

1 - 3 7

The digital computing system as a device for numeric and non numeric transformation of numbers and symbols. Constants, variables and arrays; arithmetic and logical expressions; functions. Algorithms, represented by flow chart and computer languages. Conditional branching and looping; iteration; sub-programs; input/output. All of the above will be illustrated and implemented using the FORTRAN IV language. Applications will include root finding, numerical integration, sorting, iterative design and graph plotting.

APS 299 PRACTICAL EXPERIENCE

Students in the programs listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Program 1 600 hours

Program 6 600 hours

Program 2 600 hours

Program 8 600 hours

APS 401S SOCIAL IMPACT OF TECHNOLOGY

IV-1, 2, 3, 4, 5, 6, 7, 8 (elective)

1 - 4 8

An interdepartmental seminar guided by interpretive lectures and based on intensive study of a number of diverse cases illustrating the effects of engineering works on communities and society. Examples; STOL transportation; world-scale petrochemical plant in Sarnia; engineering design and occupational health; projected energy supply for Ontario to 2000 A.D.; engineering and genetics; services for northern communities. Enrollment limited.

COCKBURN CENTRE FOR ENGINEERING DESIGN

CED 101S ENGINEERING DESIGN

I-1,2,3,4,5,6,7,8 (elective)

2 1.5 1 8

Lectures will deal with the sequence of design steps by which engineers find acceptable solutions for technological needs. These include need definition, ideation, problem modelling, feasibility and economic analysis, the decision process, specification and presentation. A series of seminars will be used to study "case" problems and to consider such topics as the engineer's responsibility to society. Laboratory time will be devoted to small group design projects. Textbook: Vidosic, Elements of Design Engineering.

I.G. Currie

CED 201S ENGINEERING DESIGN

II-5 (elective)

- - 6 8

This course provides instruction and experience in the application of engineering design techniques that lead from a stated technological need to an acceptable solution. Students work in small groups on design projects and will have lecture/discussion sessions on problem identification, ideation, design criteria, feasibility analysis and decision making. Special topics related to the projects, such as materials, economics, reliability, etc., will be covered as required. The projects will be carried through to the drawing and specification stage and, if possible, a prototype constructed. The submission of a formal project report and an oral presentation are required.

A.A. Haasz

CED 401Y PROJECT DESIGN

IV-1,2,3,4,5,6,7,8 (elective)

- 2 3 8, - 2 3 8

This elective provides an unusual opportunity for small interdisciplinary student design groups to look at problems of social or technical relevance, to seek viable solutions, and, after having a prototype constructed, to test the proposed solution. Emphasis is placed on management of the design project and on group effectiveness. Considerable freedom is given in selecting a problem and in structuring the group to suit the interests and expertise of those participating. Usually three or more groups, with from three to ten members representing the various disciplines, will each complete separate two-term projects. Oral presentations of the results are made to a student audience and a report of each project is published. This course may be used for all or partial thesis requirements by arrangement with the student's department. A list of projects completed by previous classes and examples of the reports may be obtained from I.W. Smith, Room 229, Mechanical Building.

I.W. Smith

DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

CHE 101S CHEMICAL ENGINEERING PROJECTS

I-1,2,3,4,5,6,7,8 (elective)

- - - 8

A course concerning several topics of wide interest to engineers, in which each student may choose three Chemical Engineering Projects during the term. Each five week project is given by a specialist in his field of interest and includes laboratory sessions during which the student may design and execute a particular investigation related to the lecture course. Some of the projects include:

Separation Processes (MacElhinney)
Nuclear Kinetics (Hewitt)
Environmental Chemistry (Phillips,C.R.)
Fiber Engineering (Rozeiu)
Combustion (Sandler)
Polymer Engineering (Williams)
Photochromic Tracers (Hummel)
Ceramic Engineering (Barham)
Photochemical Smog (Boocock)
Rheology (Chaffey)

Mineral Processing (Hewer)
Plastics Engineering (Woodhams)
Chemical Complexes (Smith,
Burgess)
Catalysis (Phillips,M.J.)
Composite Materials (Piggott)
Biomedical Engineering (Wang)
Insulin (Bett)
Bioengineering (Wayman)
Electricity as a Reactant
(Poulkes)

A topic will be given in any year in which more than 20 students elect to take it.

R.T. Woodhams and Staff in Chemical Engineering

CHE 111F CHEMISTRY

I-1,2,3,4,6,7,8

3 3 1 12

A basic course in physical chemistry covering the topics listed under CHE 112F but intended for students with little previous exposure to chemistry or inadequate training in chemistry.

S. Sandler and Staff in Chemical Engineering

CHE 112F CHEMISTRY

I-1,2,3,4,6,7,8

3 3 1 12

A general course in physical chemistry involving problems dealing with industrial and engineering applications. Topics discussed are stoichiometry and the mole concept, ideal and real gas behaviour, phase equilibria and colligative properties of solutions, chemical and ionic equilibrium, electrochemistry, thermochemistry and chemical kinetics.

The lecture course is supplemented by a series of laboratory experiments illustrating the principles discussed. Experiments include a gas-chromatographic study of fuel combustion, a study of caustic-chlorine, sulphuric acid and formaldehyde pilot plants, freezing point depression, molecular weight determination and binary distillations, qualitative analysis, heat of neutralization, kinetics, corrosion, pH and electro-chemistry.

S. Sandler and Staff in Chemical Engineering

CHE 113F CHEMISTRY

I-1,2,3,4,6,7,8

3 3 1 12

An enriched course in physical chemistry covering the topics listed under CHE 112F but intended for students who desire to learn as much about the subject matter as possible. Students entering Chemical Engineering and having Grade 13 chemistry or its equivalent are advised to take this course.

S. Sandler and Staff in Chemical Engineering

CHE 150F CHEMISTRY

I-5

3 3 1 10

An introduction to physical chemistry. The lectures include the following topics: ideal and real gas behavior, phase equilibria and the Clausius-Clapeyron equation, colligative properties of solutions, chemical equilibria and the Gibbs free energy, electrochemical cells and the Nernst equation, and thermochemistry. The laboratory provides experiments illustrating the principles discussed in the lectures.

W.H. Burgess and Staff in Chemical Engineering

CHE 201F PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING I

II-6

2 - - 5

The following topics are discussed: PVT behaviour of fluids and fluid mixtures (equations of state, principle of corresponding states, compressibility factors, etc.), reaction stoichiometry, energy conversion and thermochemistry, phase equilibrium and phase diagrams.

R.W. Missen

CHE 202S PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING II

II-6

2 3 - 8

This course provides an introduction to chemical thermodynamics and chemical kinetics. The second law of thermodynamics is discussed and applied to solutions, phase equilibrium, reaction equilibrium, including cell reactions and surfaces; in kinetics attention is focussed on ideal reactor models, rate laws, reaction mechanisms and catalysis. Laboratory work involves experiments for both CHE 201F and CHE 202S.

R.W. Missen

CHE 204F ANALYTICAL CHEMISTRY

II-6

2 10.5 - 14

The course consists of experimental work and lectures on qualitative and quantitative chemical analysis, illustrating the principles of equilibrium and coordination chemistry and of important instrumental methods, in particular electroanalytical and opticometric methods. The growing role of analytical chemistry in environmental engineering and in the setting of environmental standards will be discussed by way of examples. Experimental work can include an independent project designed to advance the knowledge in a selected field. Textbook: D.A. Skoog and D.M. West, Fundamentals of Analytical Chemistry, 2nd ed.

J.W. Smith, C.R. Phillips

CHE 205F INDUSTRIAL PROCESS OPERATIONS I

II-6

3 - 2 9

The theory of momentum and heat transfer and the fundamentals of momentum, heat and mass balances of chemical engineering practice are discussed. A tutorial problem class accompanies this course. Textbooks: Faust et al, Principles of Unit Operations; Himmelblau, Basic Principles and Calculations in Chemical Engineering.

W.G. MacElhinney, I.H. Spinner

CHE 206S INDUSTRIAL PROCESS OPERATIONS II

II-6

3 6 2 13

The fundamentals of transfer processes are discussed with particular reference to heat transfer operations in chemical engineering. A laboratory illustrating the principles and practice of transfer operations is also given. A tutorial problem class accompanies the lecture material. Textbooks: Faust et al, Principles of Unit Operations; McCabe & Smith, Unit Operations of Chemical Engineering.

W.G. MacElhinney, J.W. Smith, I.H. Spinner, M.J. Phillips

CHE 207S ORGANIC CHEMISTRY I
II-6

3 3 - 10

An introductory lecture and laboratory course in organic chemistry, with emphasis on structure. Textbook: Griffin, Modern Organic Chemistry.

W.H. Rapson, Z. May, D.G.B. Boocock

CHE 209F CHEMICAL SYSTEMS
II-5

3 3 - 8.5

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in various engineering fields. Laboratory work illustrating the principles with emphasis on individual projects accompanies the lectures.

R. Luus

CHE 210S APPLIED MATHEMATICS IN CHEMICAL ENGINEERING I
II-6

2 - 1 6

Applications of probability and statistics to chemical and chemical engineering problems. The course includes material on quality control, sampling inspection, tests of significance, confidence intervals and least squares.

I.H. Spinner, R.F. Hunter, D.E. Cormack

CHE 217F INORGANIC CHEMISTRY I
II-6

2 - - 5

Periodicity in physical and chemical properties of the elements are studied in relation to atomic structure. Descriptive chemistry of representative and some transition elements are correlated with structure. Textbook: Mahan, University Chemistry (third ed.).

R.E. Jervis, D. Barham

CHE 218S INORGANIC CHEMISTRY II
II-6

2 - - 5

Useful quantum models are developed for atoms and for atomic and molecular orbital bonding mechanisms. Concepts discussed include: electronegativity, Z-effective, ionic compounds, covalent bond lengths and energies, partial ionic character of bonds, coordination and complexation.

R.L. Hummel

CHE 301F THERMODYNAMICS AND KINETICS I
III-6

3 6 2 14

The power sources which have supported our civilization are ultimately based on the exploitation of chemical potentials. This course is an examination of the ultimate energy transformation and the rates at which they may be provided, together constituting a complete description of the Gibbsian power sources.

Laws of conservation and the concept of entropy together with theories of chemical reaction rates and mechanisms of selected chemical processes will be discussed in an historical context. These concepts will be illustrated by chemical engineering problems encountered in the design and operation of the means of production.

W.F. Graydon, W.H. Burgess, C.E. Chaffey

CHE 302S THERMODYNAMICS AND KINETICS II
III-6

3 6 2 14

A re-statement of the material described in course CHE 301F with additional quantitative applications taken from Chemical Engineering practice.

W.F. Graydon, W.H. Burgess, C.E. Chaffey

CHE 303F THERMODYNAMICS AND KINETICS I
 III-5c 2 3 1 10
 Course CHE 301F with reduced laboratory and tutorial assignments.
 W.F. Graydon

CHE 304S THERMODYNAMICS AND KINETICS II
 III-5c 2 3 - 9
 Course CHE 302S with reduced laboratory and tutorial assignments.
 W.F. Graydon

CHE 309F ORGANIC CHEMISTRY II
 III-6 3 9 - 14
 A continuation of course CHE 207S. Textbook: Morrison & Boyd, Organic Chemistry.
 W.H. Rapson, Z. May, D.G.B. Boocock

CHE 310F MASS TRANSFER OPERATIONS I
 III-6 2 - 2 8
 The study of the fundamentals of mass transfer. Theory and practice of applications to gas-liquid mass transfer processes, including gas absorption, stripping, drying and humidification. Textbook: R.E. Treybal, Mass Transfer Operations, 2nd ed.
 D. Mackay, O. Trass

CHE 311S MASS TRANSFER OPERATIONS II
 III-6 2 4.5 1 11
 The study of distillation, including extractive and azeotropic distillation, solvent extraction, adsorption, membrane separation and other separation processes. Illustrative laboratory experiments. Textbook: R.E. Treybal, Mass Transfer Operations, 2nd ed.
 D. Mackay, M.V. Sefton, R.F. Hunter, D. Basmadjian

CHE 312F MASS TRANSFER OPERATIONS I
 III-5c; III-2B 2 - 2 8
 Course CHE 310F but with alternative assignments.
 D.E. Cormack

CHE 313S MASS TRANSFER OPERATIONS II
 III-5c 2 - 1.5 8
 Course CHE 311S with no laboratory assignments, and alternative tutorial assignments.
 D.E. Cormack

CHE 314S FLUID MECHANICS
 III-6, III-2B 3 1.5 1 10
 Laminar and turbulent flow of Newtonian and non-Newtonian fluids, fluid-particle systems, two-phase flow, natural and forced convection heat transfer, analogies between momentum and heat transfer, types of pumps; important applications of fluid mechanics and heat transfer in the process industries and the environment.
 M.E. Charles, D.E. Cormack

CHE 316S CHEMICAL ENGINEERING PROBLEMS AND LABORATORY
 III-5c - 3 2 7
 Laboratory experiments and problems illustrating selected topics discussed in subjects CHE 303F and CHE 317S.
 W.H. Burgess, W.F. Graydon

CHE 317S POLYMER CHEMISTRY
III-5c

3 - - 8

An introductory course in the chemical structures and syntheses of polymeric materials including resins, plastics, elastomers and fibers. Emphasis will be placed on the more important commercial polymeric materials and their chemical modification by cross-linking, grafting and vulcanization. Textbook: K.J. Saunders, Organic Polymer Chemistry, Chapman and Hall (Methuen) 1973.

R.T. Woodhams

CHE 319F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING II
III-6

2 - 1 6

Applications of probability and statistics to chemical and chemical engineering problems. The course includes material on quality control, sampling inspection, test of significance, confidence intervals and least squares. Offered 1975-76 only.

I.H. Spinner, R.F. Hunter

CHE 320S CHEMICAL ENGINEERING TOPICS I
III-6

3 - - 6

The following topics are covered:

Chemical Engineering Economics

A systems approach to planning chemical enterprises. The objectives, profitability and benefit-cost analyses are discussed, as are criteria for engineering decision making and typical Canadian and overseas engineering projects. Textbooks: Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers; de Neufville and Stafford, Systems Analysis for Engineers and Managers.

M. Wayman

Nuclear Process Fundamentals

Nuclear topics basic to the nuclear engineering and radiochemistry electives in subsequent terms. Topics treated will include: nuclear composition and energetics, spontaneous and induced nuclear processes, radioactivation, nuclear fission, neutron production and radiation interactions, elements of nuclear measurement.

R.E. Jervis

Design and Analysis of Experiments

Analysis and solution of chemical engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The application of probability to selected topics of chemical engineering interest.

I.H. Spinner

CHE 321F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING II
III-6

2 - 1 6

Application of differential equations to problems of chemical engineering interest, and modelling of simple systems. Emphasis is on the formation of the differential equations together with their solution by analytical and numerical methods.

D.E. Cormack

CHE 322F INTRODUCTORY ORGANIC CHEMISTRY

III-5c

2 3 - 8

A condensed introductory organic chemistry course. Topics covered include: the bonding of carbon, nomenclature, the preparation, reaction, and identification of functional groups, industrial applications and simple electronic effects. The laboratory course will emphasize simple techniques and illustrate common organic chemical reactions. Textbook: Morrison and Boyd, Organic Chemistry.

Z. May, D.G.B. Boocock

CHE 342S NUCLEAR REACTOR FUNDAMENTALS

III-5nt,5p

3 1.5 - 8

This course, using appropriate mathematic tools, explains in terms of fundamental physical processes the design considerations and operational behaviour of existing, projected, and conceptual nuclear reactor systems for the generation of useful energy or radiation products. The physical processes of importance are nuclear fission, nuclear fusion, neutron diffusion, and the interaction of various types of radiation with matter. Topics include the conditions for criticality, the kinetic behaviour and the control of fission chain reactors, as well as the projected criteria whereby controlled fusion will become a reality. Environmental aspects and the international implications of nuclear energy will be discussed. The laboratory periods provide a first-hand opportunity to study the kinetic response of the SLOWPOKE critical reactor and to perform reactor physics measurements on the uranium heavy-water neutron multiplying assembly. The use of radiation sources and modern nuclear instruments in a variety of applications is investigated. Electrical analogs are used to supplement kinetic studies of reactor systems. (Prerequisite: PHY 335F or equivalent) Textbook: Lamarsh, Nuclear Reactor Theory, Addison-Wesley.

J.S. Hewitt

CHE 350 FOOD ENGINEERING

Food Science

The purpose of the course is to illustrate the common relationship between basic chemical engineering principles and the fundamentals of food processing. The theory of momentum, heat and mass transfer, material and energy balances, used in food engineering are discussed. The fundamentals of transfer processes are given in the lectures and are illustrated in the laboratory on a small pilot plant scale. Textbooks: Charm, Fundamentals of Food Engineering; Faust et al., Principles of Unit Operations; McCabe and Smith, Unit Operations of Chemical Engineering. (OFFERED 1976-77 ONLY)

W.G. MacPhlinney

CHE 401F CHEMICAL ENGINEERING TOPICS II

IV-6

3 - - 7

The following topics are covered:

Chemical Reactor Design

The various types of chemical reactors used in industrial processes are discussed with emphasis on the factors involved in their selection and design. The factors include flow and contacting patterns, reaction kinetics, reactor configuration, product distribution, catalysis and temperature and pressure effects.

R.W. Missen

Introduction to Process Control

An introductory course outlining methods of measurement, signal transmission and controller action. Modelling and analysis of control systems.

I.H. Spinner

Material Properties

An introduction to plastics, ceramics and metals and their properties with particular emphasis on corrosion and materials selection procedures.

M.V. Sefton

CHE 402F CHEMICAL ENGINEERING THERMODYNAMICS

IV-6, IV-5c (elective)

2 - 1 7

Thermodynamic properties of real gases and of ideal and non-ideal liquid solutions. Chemical reaction equilibria. Selected problems.

W.H. Burgess

CHE 404F TOPICS IN APPLIED CHEMICAL THERMODYNAMICS

IV-6 (elective)

2 - 1 7

Chemical process applications of thermodynamics including compression and expansion of fluids, refrigeration and cryogenics, phase equilibrium in separation processes and reaction equilibrium in reactor processes; description of real systems in thermodynamic terms, including use of fugacity and excess functions, is developed concurrently. (NOT OFFERED 1976-77).

R.W. Missen

CHE 405F CHEMICAL PLANT DESIGN

IV-6 (elective)

- - 6 7

This is a course based on synthesis and creativity. Teams of about 6 students each design and cost a chemical plant. The plants are chosen based on current Canadian needs and interests.

M. Wayman

CHE 406F CHEMICAL PLANT DESIGN

IV-5c (elective)

- - 6 9

CHE 405F with alternative assignments.

M. Wayman

CHE 407F PROCESS MODELLING AND SIMULATION

IV -6 (elective)

2 - 3 7

Extensive practice in the setting up and solving of mathematical models of a large variety of processes connected with the chemical, metallurgical and other industries, as well as environmental and biomedical phenomena. Models involve the application of chemical engineering fundamentals (fluid flow, heat and mass transfer, chemical thermodynamics and kinetics) to the simulation of steady and unsteady state processes. Solution by analytical and numerical methods. Reference book: D. Basmadjian, Process Modelling Manual.

D. Basmadjian

CHE 408F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV-6 (elective)

2 3 - 7

The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products.

R.F. Hunter, I.H. Spinner

CHE 409F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT

IV-5c (elective)

2 3 - 9

CHE 408F with alternative assignments.

R.F. Hunter, I.H. Spinner

CHE 410F ADVANCED SEPARATION PROCESSES

IV-6,5c (elective)

2 - 1 7

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, and solid-liquid contacting operations. Illustrative design problems. Textbook: C.J. King, Separation Processes

M.V. Sefton

CHE 412F PIPELINE TRANSPORTATION

IV-6 (elective)

2 - 1 7

A course based on the theory and practice of moving gases, liquids and solids by pipelines both within chemical plants and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study.

M.E. Charles

CHE 413S COMPOSITE MATERIALS

III5m, IV-6,8 (elective)

2 - 1 7

A course on the fundamentals of composite material design, fabrication and evaluation. Topics will emphasize recent developments in the reinforcement of plastics and metals using fibers, flakes, and other particulate fillers. Examples will include the use of such composites in automotive, marine, aircraft, building construction and allied engineering applications. Textbook: N.J. Parratt, Fibre Reinforced Materials Technology.

M.R. Piggott

CHE 415F POLYMER ENGINEERING

IV-5m,6 (elective)

2 - 1 7

The solid state properties of polymers are discussed, particularly amorphous state and crystallinity. The rheological and viscoelastic properties are then outlined and the effect on these of degradation and failure mechanisms included. A large segment of the course applies to fabrication techniques, their principles, and the products produced. The over-all emphasis is on the relationship of the properties to the structure, and how these affect the uses.

H.L. Williams

- CHE 417F PULP AND PAPER CHEMISTRY, TECHNOLOGY AND ENGINEERING
IV-6(elective) 2 - 1 7
The chemistry of wood in relation to pulping, bleaching and papermaking processes, the equipment involved and the economics of converting wood into paper. (NOT OFFERED 1976-77)
W.H. Rapson
- CHE 418S APPLIED NUCLEAR CHEMISTRY
IV-6,III-5m (elective) 2 - 1 7
An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics, chemical process development and process control, nuclear reactions applied to chemical analysis (activation analysis), radiation chemical processing.
R.E. Jervis
- CHE 420S CERAMICS
IV-6,2B 2 - 1 7
An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-temperature experimental techniques.
D. Barham
- CHE 423S ENVIRONMENTAL ENGINEERING
IV-2B; IV-6, 5c (elective) 2 - 1 7
Strategy (management, law, economics) and technology for environmental control of chemical processes. Dispersion and effects of effluents in the environment. Environmental impact studies. Specifically the following are discussed: environmental standards and their bases, measurement parameters and methods, sampling and monitoring, atmospheric reactions and behaviour of wastes in water bodies, meteorological principles and dispersion, water treatment principles (primary, biological, physical and chemical) and air pollution control principles (particles and gases).
C.R. Phillips
- CHE 425S INSTRUMENTAL METHODS
IV-6 (elective) 2 - 1 7
The subject is designed to emphasize the science of chemical instrumentation. The principles, techniques, and applications of gas-chromatographic, opticometric, electrometric and mass-spectrometric methods of analysis are studied.
S. Sandler
- CHE 426S ADVANCED INORGANIC CHEMISTRY
IV-6 (elective) 2 - 1 7
Periodicity and trends in physical and chemical properties of the compounds of the principal elements are discussed. These are correlated, predicted and classified both in terms of classical concepts and equations of quantum mechanics.
R.L. Hummel

CHE 427F INTRODUCTION TO NUCLEAR ENGINEERING

IV-5m,6,8 (elective)

2 - 1 7

Nuclear engineering aspects of: nuclear constitution and properties including cross-sections, energetics, radioactivity; production and use of radio-isotopes; neutrons, slowing-down, diffusion of thermal neutrons; fission, the fission reactor; heat transfer; radiation measurement and control; materials for reactor fuel, can, moderator and coolant and their behaviour in the nuclear environment. Textbook: J.R. Lamarsh, Introduction to Nuclear Engineering, or A.R. Foster and R.L. Wright Jr., Basic Nuclear Engineering, 2nd Edition.

D.G. Andrews

CHE 429S NUCLEAR REACTORS AND INSTRUMENTS

IV-7,5e (elective)

2 1.5 1 8

The purpose of this course is to provide electrical engineering students with an orientation in the nuclear energy field and to develop in terms of the basic physical processes involved an understanding of (1) the kinetic behaviour of nuclear reactor systems and (2) the principles of operation of nuclear instruments for application in industry, medicine and nuclear research. The six laboratory periods associated with this course provide intensive involvement with actual nuclear facilities including the SLOWPOKE critical reactor, the uranium-heavy water neutron multiplying assembly, and modern radiation spectrometers. In addition, special laboratories stress the fundamental aspects of nuclear radiation measurement and reactor analog simulation.

J.S. Hewitt

CHE 431S OPTIMAL CONTROL

IV-6 (elective)

2 - 1 7

Fundamentals of optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: Lapidus and Luus, Optimal Control of Engineering Processes.

R. Luus

CHE 432S CHEMICAL REACTORS

IV-6, 5c (elective)

2 - 1 7

An introduction to the rational design and analysis of chemical reactors. Topics are: chemical kinetics and development of the rate law, including homogeneous and heterogeneous systems and catalysis; reactor models (batch, tubular, stirred-tank), including isothermal, non-isothermal and adiabatic operation. Reference Books: K.G. Denbigh, Chemical Reactor Theory; O. Levenspiel, Chemical Reaction Engineering.

P.W. Missen

CHE 434S SELECTED TOPICS IN ORGANIC CHEMISTRY

IV-6,5c (elective)

2 - 1 7

A course on the creative aspects of applied organic chemistry. The topics to be discussed are selected from the Nobel Lectures delivered annually since 1902, and from outstanding Canadian contributions to synthetic organic chemistry. Special attention will be given to the mechanisms and the influence of molecular structures on the course of reactions. Various experimental techniques and their operating principles used in applied organic chemistry will be explained. Methods for the sequential degradation and the reconstruction of complex organic molecules will be illustrated with particular references to carbohydrates, proteins, heterocyclic compounds, steroid hormones, and alkaloids.

P.Y. Wang

CHE 435F RATE PROCESSES I

IV-5c

3 - - 9

Introduction to momentum, heat and mass transfer. Transport properties from kinetic theory of gases. Fluid flow concepts, integral mass, force and energy balances, Bernoulli's equation, friction. Equations of motion and boundary layer equations. Turbulent transport. Compressible flow.

O. Trass

CHE 436S RATE PROCESSES II

IV-5c

3 - - 8

Total energy and thermal energy equations. Heat Transfer: Fourier's laws, heat transfer coefficients and equations. Component mass balances, mass transfer coefficients and Fick's laws. Momentum, heat and mass transfer analogies. Applications of the above fundamentals.

O. Trass

CHE 437F OPTIMAL CONTROL OF CHEMICAL SYSTEMS

IV-5c (elective)

3 - 1.5 9

Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: Lapidus and Luus, Optimal Control of Engineering Processes.

R. Luus

CHE 440S MODELLING AND SIMULATION OF CHEMICAL SYSTEMS

IV-5c (elective)

3 - - 9

Applications of elements of chemical and physical rate processes to Chemical Engineering problems. Chemical reactor stability, complex chemical system dynamics and process control. Application of analog, digital simulation, and hybrid computers to the solutions of problems in the above topics.

I.H. Spinner

CHE 443Y ORGANIC CHEMISTRY
(elective)

2 3 - 8, 2 3 - 8

A comprehensive, elementary, organic chemistry course available to students in any year other than those enrolled in Program 6, intending to qualify for entrance into the Faculty of Medicine. Lectures and laboratories are scheduled at times convenient to those registered. The lectures cover the simple hydrocarbons, their halogen and oxygenated derivatives, amino derivatives, and other derivatives of importance to biological systems, all with emphasis on structure and functionality. The major part of the course is spent on amino acids, sugars, and fatty esters with emphasis on natural and synthetic polymers of biological interest or use. The concurrent laboratory emphasizes typical laboratory reactions of these classes of materials.

Z. May H.L. Williams

CHE 444S PLASTICS ENGINEERING
IV 5c,5m,6 (elective)

2 - 1 7

An intensive study of the chemical and physical properties of plastics materials and their use in product design. The principles of reinforcement with respect to fillers, fibers, flakes and microballoons will be presented including the practical aspects of materials selection, processing, fabrication and evaluation. The tutorial periods will be devoted to actual case histories involving recent developments. Reference Book: The Modern Plastics Encyclopedia. Textbook: G. Lubin (ed.), Handbook of Fiberglass and Advanced Plastics Composites, Van Nostrand Reinhold (1969).

R.T. Woodhams

CHE 445S PETROLEUM ENGINEERING
IV-6 (elective)

2 - 1 7

A course utilizing the principles of Chemical Engineering and presenting the fundamentals of engineering design and processing as they apply to refinery operations that produce petroleum products and important chemicals from petroleum.

W.G. MacElhinney

CHE 446F ATMOSPHERIC DISPERSION
IV-6 (elective)

2 - 1 7

Problems of assessing the dispersive role of the atmosphere are considered, as well as related topics such as source sampling and effects of air quality on the feasibility of industrial plants and residential areas. Textbook: Meteorology and Atomic Energy, 1968. (NOT OFFERED 1976-77)

J.W. Smith

CHE 447F CATALYSIS
IV-6 (elective)

2 - 1 7

An introduction to heterogeneous and homogeneous catalysis including adsorption, kinetics of catalytic reactions, the nature of the catalyst surface and a consideration of some specific catalytic reactions.

M.J. Phillips

CHE 448F INDUSTRIAL BIOLOGICAL PROCESSES
IV-6 (elective)

2 - 1 7

Principles involved in the industrial handling of biological materials. Engineering operations in the manufacture of biologically active substances. There will be a short discussion of protein chemistry with emphasis on enzymes and protein hormones. One or more visits will be arranged to a plant operating in the biological field.

H.D. Bett

CHE 449S NUCLEAR CHEMICAL ENGINEERING

IV-6 (elective)

2 - 1 7

Nuclear reactor fuel cycles; large-scale production of transuranium elements; growth and decay of fission product nuclides; chemical processing of irradiated fuels - extraction, absorption, complexing, chemical separation; transport and storage of radioactive wastes; environmental problems; isotope separation by physical means - diffusion, centrifuges, cascades.

D.G. Andrews

CHE 452F NUCLEAR SYSTEMS ANALYSIS

IV-5nt

2 1.5 1 8

The purpose of this course is to show how design analysis is carried out on actual nuclear reactors and other nuclear facilities. Included are the applications of multi-group neutron diffusion theory to reflected and heterogeneous thermal systems, as well as an introduction to neutron transport and its application in fast and thermal reactors. The state of current computational methods in reactor analysis will be indicated. Safety analysis and the licensing of nuclear installations will be discussed.

Staff in Chemical Engineering

CHE 453S ELECTROCHEMISTRY AND CORROSION

IV-6,5c (elective)

2 - 1 7

This is an introductory course in electrochemistry and corrosion which has been designed to provide the student with a working knowledge of the subject areas. The topics covered include the physical chemistry of electrolytes, Faraday's laws, conductivity and ion transport in solution, electrodes, electrode kinetics, industrial applications (the electrolytic process industries, fuel cells; batteries, electrodialysis), and corrosion and corrosion control.

F.R. Foulkes

CHE 454F ENERGY, ENVIRONMENT, AND RESOURCES

IV-6 (elective)

2 - 1 7

Society is moving steadily towards decreased dependence on non-renewable energy and material resources while seeking to ensure maintenance of a satisfactory environment. The role of applied chemical science in these changes is described with emphasis on Canadian conditions. Topics discussed in detail include: current and future energy sources, conversion usage and conservation; process effluent treatment and elimination; resource recycling; environmental impact assessment and ecosystem analysis; resources depletion; policies to ensure beneficial technical change; Canadian Arctic development. The course will consist of lectures and individual student projects and presentations on relevant topics.

D. Mackay

CHE 455F TOPICS IN HEAT TRANSFER

IV-6 (elective)

2 - 1 7

Heat transfer is an important design and operating aspect of chemical reactors and various important separation processes of the chemical industry. The course covers the principle modes of heat transfer--conduction, convection and radiation--in conditions of steady and transient states, change of phase, and industrial conditions. The course goes beyond the standard textbook and into areas of controversy.

R.L. Hummel

CHE 456F ECONOMIC EVALUATION IN THE PROCESS INDUSTRIES

IV-6,5c (elective)

2 - 1 7

The course presents a clear conception of how to prepare and evaluate investment proposals. Practical applications will be discussed in addition to techniques and theories of investment evaluation. Emphasis will be placed on such topics as the reading and interpretation of financial statements; a firm's cost of capital; the economics and relative feasibility of new projects, plant modernization and expansion, "make or buy", "buy or lease", "replace or repair", "abandonment", and uncertainty and inflation in economic evaluations.

A.J. Szonyi

CHE 457S INNOVATION AND ENTREPRENEURSHIP FOR CHEMICAL ENGINEERS

IV-6 (elective)

2 - 1 7

The course is intended to give the students an understanding of small chemically-oriented business enterprises to introduce skills needed to run a small business. The mechanics of launching a new small enterprise and its technical, economical, legal and financial aspects will be discussed. Case histories in the chemical and process industries will be presented. Enrolment may be limited.

A.J. Szonyi

CHE 458S CHEMICAL ENGINEERING IN MEDICINE

IV-6 (elective)

2 - 1 7

Seminars on the application of chemical engineering principles to the understanding of biological phenomena, in particular human physiology, and to the solution of medical problems. Selected topics of broad current interest, such as membrane transport and artificial organ technology.

M.V. Sefton

CHE 477F INTRODUCTION TO NUCLEAR ENGINEERING

IV-3 (elective)

2 1.5 1.5 8

Course 427F with additional laboratory and tutorial assignments.

CHE 498S PUBLIC SPEAKING

IV-6

- - 3 4

Students make oral presentations before small groups involving some aspects of their thesis project and other technical subjects. Constructive criticism is provided by students and members of the senior staff.

CHE 499Y THESIS, DISSERTATION

IV-6

- 8 2 10, - 12 1 13

Normally an experimental research project conducted under the supervision of a senior staff member. The project may, however, have a theoretical or design emphasis. A progress report on the work completed in the Fall Term is required at the beginning of the Spring Term and will be weighted 20% in calculating the final grade for the course. The thesis must be submitted before the last day of lectures in the Spring Term. A significant part of the course is instruction in the Fall Term in workshop practice and public speaking.

Senior Staff in Chemical Engineering

DEPARTMENT OF CIVIL ENGINEERING

CIV 100F APPLIED MECHANICS

I-1,2,3,4,6,7,8

3 - 2 10

Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames are examined. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy and momentum concepts are applied to particles, systems of particles and rigid bodies. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful.

R.H. Mills and Staff in Civil & Mechanical Engineering

CIV 101F MECHANICS (STATICS)

I-5

2 - 1 6

Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium are considered.

S.M. Uzumeri, B. Etkin

CIV 135F/S ENGINEERING GRAPHICS

I-1,2,3,4,6,7,8

2 5 - 8

A course to provide an introduction to graphical communication in contemporary engineering practice. Topics in descriptive geometry and engineering drawing include orthographic projection, single view drawings, spatial analysis, developments and intersections, sketching, preparation of graphs and nomographs and the reproduction of drawings.

J. Timusk and Staff in Civil Engineering

CIV 136S ENGINEERING GRAPHICS

I-5 (elective)

2 - 2.5 8

A course on the use of graphical theories and methods as a means of visual communication in the development of engineering concepts. The lectures and laboratory problems deal with the ideas, problem refinement, solution analysis and solution implementation.

R.D. Foster

CIV 203S MECHANICS OF MATERIALS

II-5 (elective)

2 - 3 8

Structural design philosophy and methods; structural properties of engineering materials: basic relationships between force and deformation of bars; behaviour of structural components subject to axial load, bending, shear, and torsion; stress and strain transformations; instability; design of simple structures.

CIV 204F MECHANICS OF MATERIALS

II-8

3 1.5 - 8

The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various engineering materials. The buckling of struts and columns is examined. Laboratory: An experimental study of engineering materials and structural members under various loading conditions. (Prerequisite: CIV 100F)

A.C. Davidson

CIV 205S MECHANICS OF MATERIALS

II-4 (elective)

2 3 - 8

An introduction to the elastic behaviour of solids under various load conditions. The basic concepts of strength and stiffness are examined and their application to the design of elementary structural systems considered. Laboratory: An experimental study of engineering materials and structural members under load. (Prerequisite: CIV 100F)

J.D. Barber

CIV 209F ENGINEERING MATERIALS

II-1

4 2 1 9

Deals with the basic principles necessary for the undertaking and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed. One third of the laboratory time is devoted to demonstrations illustrating the fundamentals covered in the lectures, the remaining time to project work in small groups (Co-requisite: CIV 210F)

J. Timusk, G.B. Craig

CIV 210F STRENGTH OF MATERIALS

II-1,2

3 - 2 8

An introduction to the elastic and inelastic behaviour of solids under various load conditions. Stress, strain, and deformation relations are determined for members subjected to tension, compression, torsion and bending forces. (Prerequisite: CIV 100F)

J. Schwaighofer, P.M. Wright

CIV 211S STRUCTURES I

II-1

4 - 2 10

As an introduction to structural engineering design, the topics include the study of loads, safety factors, structural members and systems. Continuing study of structural mechanics fundamentals covers virtual work, energy methods, stability, influence lines, and an introduction to vibration. (Prerequisite: CIV 210F)

S. Otani, S.M. Uzumeri

CIV 240S ENVIRONMENTAL SYSTEMS

II-1; IV-2C (elective)

2 1 - 6

An examination of the causes of environmental deterioration (through population growth, economic growth, urbanization and industrialization, resource exploitation and recreation) and their effects on natural and man-made systems. Technology of water, air, soil and noise pollution control. Examination of alternative strategies for environmental management.

G.W. Heinke

CIV 255F SURVEYING

II-1

3 2 1 9

General principles and practice of surveying including: measurement of horizontal distances, horizontal angles, vertical distances. Survey calculations, sources of errors, corrections and adjustments. Route surveying, construction surveying and introduction to airphoto interpretation and photogrammetry.

B.J. Haynes, H.L. Macklin

CIV 260F COMPUTER PROGRAMMING

II-1

2 - 2 7

This course continues the study of programming requirements and techniques introduced in course APS 100F/S; the full standard FORTRAN language is used; emphasis is placed on subprogram philosophy and organization, and on flow charts and program documentation. Engineering problem oriented languages such as ICES-COGO and ICES-STRUDL are introduced and used. Some experience is provided in the use of a time-shared interactive computing system and in computer graphics. (Prerequisite: APS 100F/S)

R.A. Collins, P. Byer

CIV 267S CIVIL ENGINEERING PROJECTS

II-1

2 2 2 8

An introduction to the role of the engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to engineering problems. Instruction and practice in presentation of technical data and reports.

Staff in Civil Engineering

CIV 271S PROBABILITY AND STATISTICS

II-1,2

3 - 2 8

An introductory course which combines the theory of probability, including Binomial, Poisson, and normal distributions, frequency and sampling distributions, parameter estimation, hypothesis testing, experimental design and linear regression, with practical examples and exercises related to Civil Engineering.

G.N. Steuart, B.J. Adams

CIV 280F ELEMENTS OF STRUCTURAL ENGINEERING

Architecture (elective)

2 - 2 6

Intended primarily for students in Architecture, this course examines the fundamentals used in the analysis and design of building components. Topics to be covered include equilibrium principles, introduction to the structural properties of common building materials and to basic strength of materials. Finally these fundamentals are used in the design of some simple structures. Students not in Architecture require prior permission of the instructor to register for this course.

P.M. Wright

CIV 281H SURVEYING

Forestry

1.5 1 0.5 4

A lecture course covering the basic principles of plane surveying, including the following: sources of error; survey computations; simple and parabolic curves; stadia and topographic surveys; earth-work surveys and calculations; lay-out of gravity flow pipelines.

B.J. Haynes

CIV 312F STRUCTURES II

III-1

3 - 2 9

This course emphasizes the design of elastic determinate systems. Practical examples in designing and detailing of structures in steel and timber are studied. (Prerequisite: CIV 211S)

J.D. Barber

CIV 313S STRUCTURES III

III-1

3 - 2 9

This course deals with the analysis of indeterminate systems and introduces the design of reinforced concrete structures. Practical design of reinforced concrete members such as columns, beams, and one-way slabs are studied using the ultimate strength design method. (Prerequisite: CIV 312F)

J. Schwaighofer

CIV 314S STRUCTURAL DESIGN

III-2C

2 - 3 8

This course is an introduction to the design of steel, timber and reinforced concrete structures. Topics to be covered include types of loads, specifications, design of beams and columns, design of reinforced concrete slabs and an examination of the structural systems for light industrial buildings. (Prerequisite: CIV 210F)

CIV 321F SOIL MECHANICS

III-1,2C

3 1 - 7

Introductory course dealing with identification of soils for engineering purposes; permeability and seepage; in situ stresses, ground-water pressures, effective stresses; volume compressibility and time-rate of volume change; shear strength. Laboratory sessions include identification of soil samples and determination of mechanical properties of soil. (Prerequisite CIV 210F).

T.C. Kenney, J.-C. Roegiers

CIV 322S FOUNDATIONS

III-1,2C

2 - 2 7

Earth pressure, retaining walls, braced, strutted and tied-back excavations, bearing capacity, shallow foundations including spread footings, combined footings and rafts, deep foundations including piles and bored piers, settlement, slope stability. Tutorial sessions are devoted to design problems. (Prerequisites: CIV 210F, CIV 321F)

F.A. De Lory, T.C. Kenney

CIV 327S PLEISTOCENE GEOLOGY

III-2C

3 - 2 8

The causes, extent, and effects of Pleistocene ice caps, especially in North America. Origin and classification of land-forms of glacial origin. Methods of dating and analyzing these deposits. Periglacial phenomena, including permafrost. The extent of and the economic and engineering significance of glacial deposits in North America. (Prerequisites: GLG 120F/180S/280S)

J.D. Morton

CIV 330F TRANSPORTATION SYSTEMS

III-1

3 - 2 8

A brief history of Canadian transportation development and a discussion of current policy, regulation and administration structure introduces a comparative study of transportation modes including their cost characteristics. The principles of location, flows on networks and the concepts of capacity and control are studied. The transportation planning process is introduced with emphasis on analytical techniques.

G.N. Steuart, R.M. Soberman

CIV 338S URBAN AND REGIONAL PLANNING TECHNIQUES

III-1, IV-1 (elective)

3 - 2 8

This course provides an introduction to the basic techniques used by urban and regional planners in the planning process. Topic areas will include methods of analysis, forecasting, simulation techniques and the regulation of land use. Practical applications will be emphasized in a series of brief laboratory assignments.

R.W. McCabe

CIV 340S MUNICIPAL AND HYDRAULIC ENGINEERING

III-1

3 1.5 2 10

Systems for the supply, distribution and storage of water and for the collection of wastewater and stormwater are studied in detail. Other municipal problems dealt with include; pumping, stations, roads, land development, solid waste disposal and the financing and administration of public works. Individual and group design projects supplement the lectures. (Prerequisite: MEC 351F; Corequisite: CIV 240S)

B.J. Adams, D.F. Janes

CIV 358F SURVEY CAMP

III-1

- - - 8

At Survey Camp, students obtain further experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on route surveys, higher order surveys, and topographic surveys. Students entering Third Year Civil Engineering will be required to take the Survey Camp from August 23 to September 7, 1976. The camp is held at Dorset and Gull Lake with students in attendance paying for the cost of their accommodation. Applications to defer attendance or for exemption from the camp must be made to the Secretary of the Faculty before July 15, 1976. (Prerequisite: CIV 255F)

B.J. Haynes and Staff in Civil Engineering.

CIV 370F ENGINEERING MATHEMATICS

III-1, 2C

3 - 2 8

Numerical integration, solution of ordinary and simple partial differential equations by numerical procedures, solution of linear algebraic equations, mathematical programming. (Prerequisite: MAT 280F)

G.T. Will, V.F. Hurdle

CIV 375S ENGINEERING ECONOMICS AND DECISION MAKING

III-1, 2C

3 - 2 8

Design as selection between alternatives. Economic efficiency and other goals. The objective function and the use of optimization techniques. Time scale of consequences and its reduction. Interest rate and social rate of return. Market and non-market valuation. Economic life, replacement and salvage value. Treatment of risk and uncertainty. Public investment. Financing.

E. Hauer, P. Byer

CIV 405F ADVANCED STRENGTH OF MATERIALS

IV-1 (elective)

3 - 2 8

Selected topics from the following list are introduced or extended beyond their elementary treatment: elastic buckling of axially loaded bars; torsion of bars having non-circular cross sections; unsymmetrical bending of beams; beams on elastic foundations; curved beams; beam-columns; cables; rings; elementary theory of elasticity; elementary plate theory.

J. Schwaighofer

CIV 413S MODULAR CONSTRUCTION

III-1, IV-1 (elective)

3 - 2 8

Systems building approach, types of modular construction. Fundamentals of building science. Materials for modular construction analysis and design of various modular systems, including panelized construction, formless masonry construction, and prefabricated box units. Joining and erection techniques. Recent developments.

V.R. Riley

CIV 414S ADVANCED ENGINEERING MATERIALS

III-1, IV-1 (elective)

3 - 2 8

A "state of the art" review of the properties of materials used in Civil Engineering construction with special reference to design considerations and criteria for selection and specification of materials. Related project work is intended to stimulate an innovative approach to the use of materials. A strong emphasis on concrete technology reflects the responsibility of the Engineer for the quality of concrete and its importance in Civil Engineering.

R.H. Mills

CIV 416F REINFORCED CONCRETE I

IV-1 (elective)

3 - 2 8

This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. Emphasis is given to the relationship between recent research results and current building codes. (Prerequisite: CIV 313S)

S.M. Uzumeri

CIV 417S REINFORCED CONCRETE II

IV-1 (elective)

3 - 2 8

Prestressed Concrete - tension members, simple span and continuous span flexural members, columns and torsion resisting members. Slender reinforced columns. (Prerequisite: CIV 416F)

M.W. Huggins

CIV 418S BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV-1 (elective)

3 - 2 8

The behaviour of structural elements and structures and their connection by welding and bolting are examined and related to design methods and criteria. Topics to be considered include repeated loading, brittle fracture, elastic-inelastic behaviour, buckling and ultimate capacity. (Prerequisite: CIV 313S)

P.C. Birkemoe

CIV 419F INDETERMINATE STRUCTURES

IV-1 (elective)

3 - 2 8

Internal forces, support reactions, structural displacements and influence lines are computed for continuous beams, arches, closed rings, frames, trusses, Vierendeel trusses and grids. Slope-deflection, moment distribution, Kani, flexibility and stiffness methods, virtual work and Muller-Breslau principles, and Maxwell's law of reciprocal displacements are studied. An introduction to structural analysis by matrix organization is examined. (Prerequisite: CIV 313S)

R.A. Collins

CIV 420F CONSTRUCTION ENGINEERING

IV-1,2C (elective)

3 - 2 8

Consideration of the various aspects of engineered construction including selecting, planning, scheduling, estimating, bidding and controlling projects. With the aid of project slides, the methods and equipment used in the construction of power plants and dams, highways and bridges, tunnels, buildings, and marine facilities will be studied. Small groups using complete plans and specifications will solve a number of related assignments.

K.A. Selby

CIV 421F FOUNDATIONS AND EARTHWORK

IV-1 (elective); IV-2C

3 - 2 8

Design and construction of: foundations for buildings, bridges and other structures including excavation, footings, piling, caissons; retaining walls, sheet pile bulkheads; fills, embankments, earth-fill and rock-fill dams including seepage, dewatering and grouting. The laboratory sessions include design problems and studies of case histories. (Prerequisite: CIV 322S)

E.I. Robinsky

CIV 422S ENGINEERING GEOLOGY

III-1, IV-1 (elective)

3 - 2 8

The study of engineering practice from a geological point of view. The behaviour of rocks and soils in building and engineering construction, foundations, tunnels, dams, and flood-control works with reference to the importance of the mineral composition of earth and rock materials, their geomorphic and geologic features and their stress history. Engineering case studies will include examination of groundwater, frost and landslide conditions, shoreline engineering, construction in permafrost, earthquake problems, and field investigations. (Prerequisite: GLG 280S/GLG 180S Exclusion: CIV 423S)

E.I. Robinsky

CIV 423S ENGINEERING GEOLOGY SEMINARS

IV-2C

3 - 2 8

Application of Engineering Geology to construction and natural problems, for example; foundation sites, dams, tunnels, landslides, coastal erosion, permafrost. The course will consist of lectures and seminars. Students will present orally the results of individual case histories or subject studies on selected topics. The instructional portion of CIV 474S, Public Speaking will be included in this course. (Prerequisites: CIV 421F, CIV 424F, Exclusion: CIV 422S)

T.C. Kenney and Staff in Civil Engineering

CIV 424F ROCK MECHANICS

IV-1 (elective); IV-2C

3 - 2 8

Physical properties of rock, fundamentals of rock behaviour, and theories of rock failure. Consideration of in situ stresses. Analysis of stress and strain. Elementary principles of design of open excavations and underground excavations. Consideration of testing, excavation support, and instrumentation.

J.-C. Roegiers

CIV 425F SUBSURFACE EXPLORATION

IV-2C

3 - 2 8

Planning and executing subsurface explorations in soils and rock to obtain information for the design, construction control and operation of civil engineering and mining projects, and for carrying out remedial actions in the case of distressed structures or distressed areas. Indirect methods (mapping, shallow seismic, pumping, penetration), direct methods (boring, shafts, adits), in situ tests and field instrumentation will be considered. Case histories will be studied.

J. Morton

CIV 428S DESIGN OF EARTH AND ROCK STRUCTURES

IV-2C

2 - 3 8

Design of: cuttings in soil and rock, embankments and dams of earth and rock fill and openings in earth and rock such as tunnels and cavities. Consideration will be given to: appreciation of site conditions, site selection, material selection and/or exploration, design and analysis, construction control, monitoring of performance, seepage control, remedial measures. Tutorial sessions will consist of design projects. (Prerequisites: CIV 421F, CIV 424F)

E.I. Robinsky, J.-C. Roegiers

CIV 429F AIR PHOTO INTERPRETATION

IV-1 (elective); IV-2C

3 2 - 8

Aerial photography; photo pattern elements in landform identification; identification of glacial, eolian, alluvial, organic and major rock type landforms and discussion of associated engineering properties and problems; location of granular materials; soil drainage mapping; applications in highway location and site evaluation studies.

J. Vlcek

CIV 430F TRAFFIC ENGINEERING

IV-1 (elective)

3 - 2 8

The course is an introduction to the principles and techniques of traffic engineering and public transport operations. The first part is devoted to the discussion of driver, vehicle, roadway and traffic stream characteristics and their implications for design and control operations. The second part of the course deals with: highway and intersection capacity, signal timing, area traffic control, bus route design and operation, and road safety management. (Prerequisite CIV 330F).

E. Hauer, V.F. Hurdle

CIV 431F TRANSPORTATION PLANNING

IV-1 (elective)

3 - 2 8

This course deals with the transportation planning process, with emphasis on urban and regional applications. Surveys and data collection, mathematical models and transportation demand analysis, transit and highway system alternatives, methods of project and systems evaluation.

R.G. Rice

CIV 432S HIGHWAY ENGINEERING

IV-1 (elective)

3 - 2 8

A basic course in which the following topics are examined: highway systems and geometric design; highway materials and their behaviour; and, pavement systems. The laboratory part of the course is mainly devoted to a design project.

M.M. Davis

CIV 440F WATER AND POLLUTION CONTROL ENGINEERING
IV-1 (elective)

3 - 2 8

Environmental pollution, water and waste systems and the selection of pumps are reviewed briefly. Water quality, self purification of streams, soil pollution and the principles involved in the design and operation of water and wastewater treatment facilities are then studied in detail. Laboratory and field trips complement the lectures and class assignments.

J.G. Henry

CIV 441S AIR POLLUTION CONTROL ENGINEERING
IV -1 (elective)

3 - 2 8

The pollutants: their sources, quantities and qualities, effects on humans, environment. Distribution and concentrations in city air under various atmospheric conditions, pollution indices. Control processes: change of fuel, dust control by cyclones and electrostatic precipitators; control of gases by adsorbers and scrubbers; exhaust controls for vehicles. Impacts on economy, planning, policy decisions.

E. Koczur

CIV 449S GROUNDWATER
IV-2C

3 - - 8

Ground water as an element of the hydrologic cycle; its relation to the geology of a basin and to water resources management. Mechanics of groundwater flow; methods of investigation, preservation and exploitation; groundwater pollution.

E.I. Robinsky, J.-C. Rogiers, B.J. Adams

CIV 450F WATER RESOURCES AND HYDROLOGY
IV-1

3 - 2 8

Management of water resources for optimal use. Systems approach and models for water resources studies. Rainfall, run-off and stream-flow analysis. Flood and water quality control by structural and non structural methods. Hydrologic effects of urbanization. New techniques for storm water management. Benefit cost analysis. Environmental, economic, sociological, legal and political factors affecting water management: examples related to the Great Lakes and to large power developments in Canada.

B.J. Adams, P.E. Wisner

CIV 455F PHOTOGRAMMETRY AND REMOTE SENSING
IV-1,2C (elective)

3 2 - 8

Camera as a measuring instrument. Photogrammetric properties of pictures, construction viewing and measuring of stereoscopic models. Applications in engineering, and mapping. Physical aspects of remote sensing. Spectral characteristics of natural objects. Photographic and nonphotographic remote sensors and their applications in terrain studies, vegetation analysis and natural resource management. Analysis of Earth Resource Satellite data.

J. Vlcek

CIV 456S ENGINEERING APPLICATIONS OF SURVEYING

III-1, IV-1 (elective)

3 - 2 8

Theory, methods and instrumentation of engineering surveys. Special applications in civil engineering structures such as: bridges, dams, tunnels, highways, airports, power lines, and pipelines. Introduction to hydrographic surveying. Engineering applications of and introduction to legal surveying as related to engineering projects. (Prerequisite: CIV 358F)

B.J. Haynes, H.L. Macklin

CIV 468F CIVIL ENGINEERING SYSTEMS

IV-1

3 - 2 8

The analysis and design of comprehensive engineering systems by student groups, with examples from structural, geotechnical, transportation, and environmental engineering. Emphasis is placed on the evaluation of alternative technological designs and the integration of knowledge from many courses in the curriculum. Lectures and case studies are given on systems methodology, data analysis, sensitivity testing, and the incorporation of engineering, economic, and social considerations in design.

R.G. Rice, P. Byer

CIV 474S PUBLIC SPEAKING

IV-1

- - 2 3

A subject emphasizing student participation and designed to develop facility in oral presentation before groups. Beginning with short talks, students move on to longer prepared talks on technical subjects. Experience and observation are also offered in the conduct of meetings.

H.L. Macklin & Staff in Civil Engineering.

CIV 475S ADMINISTRATION AND MANAGEMENT

IV-1, 2c (elective)

3 - 2 8

An introduction to the various management functions involved in operating a business; including planning, organizing, staffing, directing, controlling and labour relations. Individual proprietorships, partnerships, and limited company operations are discussed. The practice of management in engineering environments will be studied with the aid of a number of cases.

K.A. Selby, H.L. Macklin

CIV 479F/S SPECIAL STUDIES IN CIVIL ENGINEERING

IV-1 (elective)

3 - 2 8

Students having the Departmental Chairman's approval, may undertake special studies of advanced topics that are not normally part of the undergraduate program.

G.T. Will

CIV 498F THESIS

IV-1 (elective)

- 4 - 8

With the approval of the Departmental Chairman, a Fourth year student in Civil Engineering may undertake a 20-unit thesis instead of the usual 12-unit thesis (CIV 499S). Normally such theses will be experimental in nature and the topic must be submitted prior to the commencement of the fall term.

R.H. Mills

All students in the Fourth Year of the Civil Engineering program must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. (Only those students who will complete the requirements for their degree in a fall term will be permitted to take CIV 499F.)

R.H. Mills

COMMERCE
(Department of Political Economy)

COM 390F ACCOUNTING I

2 - - 8

III-4
Accounting methods and principles; build-up of financial statements.
M.S. Shapiro

COM 391S ACCOUNTING II

2 - - 8

III-4 (elective)
Analysis and interpretation of financial statements; introduction to cost
accounting and managerial accounting. (Prerequisite: COM 390F)
M.S. Shapiro

DEPARTMENT OF COMPUTER SCIENCE

CSC 180F INTRODUCTION TO COMPUTER PROGRAMMING

I-5

2 2 - 6

A practical introduction to structural programming using PL/1; numerical and non-numerical applications.

J.N.P. Hume, R.C. Holt

CSC 280S COMPUTER LANGUAGES

II-5 (elective)

2 - 1 8

Definition of various programming languages including procedure oriented, list processing and simulation languages. Specification of syntax and semantics. Basic properties of programming languages. Introduction to formal languages and data structures. (Prerequisite: CSC 180F)

J.N.P. Hume

CSC 336S NUMERICAL METHODS

III-8

2 - 1 7

Linear systems of equations, interpolation and approximation, nonlinear equations, quadrature, ordinary differential equations. The emphasis will be on using numerical methods for the computer solution of such problems. Text: Conte and de Boor, Elementary Numerical Analysis, 2nd Edition. (Prerequisites: APS 100F/S, MAT 187S, MAT 189S. Exclusions: CSC 281F, CSC 381F, CSC 382S, CSC 383S, CSC 386F)

E. Swenson

CSC 364S INTRODUCTION TO THE THEORY OF COMPUTATION

III-5cs

2 - 1 7

Introduction to formal logic - propositional and predicate calculus. Primitive recursive functions, computable functions, recursive functions, recursive sets. Turing machines, unsolvable problems. Models, flowcharts, and program schemata; application to equivalence, termination, and correctness of programs. Text: Brainerd and Landweber, Theory of Computation, (Exclusion: CSC 390S as given before 1973-74.)

D.G. Corneil

CSC 380S SYSTEM SOFTWARE I

III-5cs

2 6 - 10

An introduction to the facilities made available by modern hardware and operating systems. Data structures, including linear and linked lists, stacks, queues, trees. The principles of language processing. Formal grammars and parsing. (Prerequisites: CSC 280S and ELE 353F)

E. S. Lee

CSC 381F NUMERICAL METHODS I

III-4

2 - 2 8

Roots of equations, interpolation, approximation theory, quadrature, numerical solution of ordinary differential equations. (Prerequisites: IND 202F, MAT 293F, MAT 294S. Exclusion: CSC 336S, 281F, 382S)

R. Mathon

CSC 382S NUMERICAL METHODS

III-3,8

2 - 1.5 8

Linear systems of equations, interpolation and approximation, nonlinear equations, quadrature, ordinary differential equations. The emphasis will be on using numerical methods for the computer solution of such problems. Text: Conte and De Boor, Elementary Numerical Analysis, 2nd Edition. (Prerequisites: APS 100F/S, MAT 187S, MAT 189S. Exclusions: CSC 281F, 336S, 381F, 383S, 386F)

R.L. Johnston

CSC 383S NUMERICAL METHODS

III-5

2 - 1 8

The study of computational methods for solving problems in linear algebra, nonlinear equations, approximation, and ordinary differential equations. The aim is to teach the student the theory behind, and the intelligent use of mathematical subroutine packages currently available in computer libraries. Exclusions: CSC 281F, 336S, 381F, 382S, 386F

R. Mathon

CSC 386S NUMERICAL METHODS II

III-4 (elective)

2 - 2 8

Matrix calculations, eigenvalues, roundoff errors, random numbers, extrema of functions of several variables. (Prerequisite: CSC 381F. Exclusion: CSC 281F, 336S, 382S, 383S)

R.L. Johnston

CSC 446S COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

IV-5cs

2 - 1 8

Initial value problems. Consistency, convergence, stability. Boundary value problems. Difference schemes, finite element methods. Mixed initial boundary value problems, nonlinear problems. (Prerequisite: CSC 281F, Recommended: APM 491F)

R.L. Johnston

CSC 458S ARCHITECTURE OF DISTRIBUTED COMPUTER SYSTEMS

IV-5cs

2 - 1 8

Theoretical design and operational considerations of distributed computer networks. Data communication, system design and social implications of distributed systems. Discussion of existing systems. (Prerequisites: CSC 380S, ELE 353S)

D.B. Wortman

CSC 468F OPERATING SYSTEMS

IV-5cs

2 - 1 8

Introduction to the design and implementation of multiprogramming operating systems. Specific topics include concurrent processes, processor scheduling, memory management, file systems, protection and security, design and implementation methodology, and performance evaluation. (Prerequisite: CSC 380S)

D. Tsichritzis

CSC 478S APPLIED ALGEBRA

IV-5cs

2 - 1 8

Algebraic theory which underlies symbolic and algebraic manipulation by computer; algebraic algorithms, Chinese remainder and interpolation theory; computation with integers, polynomial, and rational functions; symbolic matrix algorithms. The fast Fourier transform. Languages and systems for algebraic manipulation. Flowgraph theory with applications to graphs, automata, and Markov chains. (Prerequisite: MAT 390S)

J.D. Lipson

CSC 480S SYSTEM SOFTWARE II

IV-5cs

2 6 - 10

Continuation of topics in CSC 380S. Development of complete software systems. The organization of compilers, interpreters, assemblers, link editors, and loaders; tools which facilitate their construction. The laboratory associated with this course will include team projects producing pieces of system software. (Prerequisite: CSC 380S)

.C. Holt

DEPARTMENT OF POLITICAL ECONOMY

ECO 281F/S ECONOMICS FOR ENGINEERS

II-1, 2, 3, 4, 5, 6, 7, 8

3 - 1 8

A survey course that includes opportunity costs, resource allocation, micro and macro economic theory and policy related issues. The micro-economic section deals with organization and structure of Canadian industry, public sector analysis, cost benefit analysis, project evaluation and general equilibrium. The macro-economic section deals with unemployment, inflation, international trade, economic growth and the policy issues related to these topics. This course has equivalent value to ECO100 as prerequisite for advanced courses in economics. It may not be combined with ECO100, ECO102 or ECO103 in any degree program.

DEPARTMENT OF ELECTRICAL ENGINEERING

ELE 121S ELECTRICITY AND MAGNETISM

I-1,2,3,4,6,7,8

3 1 1 10

A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, electromagnetic induction, and an introduction to the conductive, magnetic and dielectric properties of materials.

ELE 150S ELECTRICITY AND MAGNETISM

I-5

3 - 1 8

An introduction to electricity and magnetism adapted to the needs of Program 5. Elements of vector calculus. Coulomb's Law. Gauss's Law. Electric field of discrete and continuous charge distributions. Potential functions. Gradient and divergence. Electrostatic forces and energy, capacitance. Forces on moving charges and conductors. Ampere's Law. Biot-Savart Law. Magnetic field of current rings and coils. Faraday's Law and Applications. Self and mutual inductance. Energy stored in a magnetic field. Circuit theory for transient and alternating currents. Electric and magnetic fields in matter. Textbook: Gartenhaus, Physics Basic Principles, vol.2

ELE 200F COMPLEX VARIABLES AND VECTOR CALCULUS

II-7

3 - 2 8

Differentiation of vector functions. Gradient, divergence and Gauss Theorem. Curl of a vector field and Stokes' Theorem. The operator Del. Applications to Electromagnetic Fields, Maxwell's equations. Theory of Complex Variables, Cauchy-Riemann Equations. Complex integrals. Cauchy's integral theorem and formula. Taylor and Laurent series. Residues. Conformal Mapping and their applications to two-dimensional potential problems. Applications of Complex Integrals to stability of systems. Textbook: Kreyszig: Advanced Engineering Mathematics-Wiley (Prerequisite: MAT 187S, MAT 189S, corequisite: MAT 290F)

ELE 201S NUMERICAL METHODS

II-7

2 - 2 6

The systematic use of the computer as a tool to assist in the solution of electrical engineering problems involving numerical calculations. The techniques of iteration, rootfinding, solution of linear equations, characteristic value problems, numerical integration, and initial value problems are included. Applications are drawn from the areas of electromagnetic fields, control systems, power systems, and circuit design and analysis (Prerequisite: MAT 290F)

ELE 210F CIRCUIT THEORY I

II-7

4 1.5 1 11

Circuits as models for physical devices; relationships between circuit and field concepts. Elementary network theorems and laws. Transient response of circuits. Topology and loop and nodal analysis. Response to complex frequency excitation. General solution of linear differential equations with constant coefficients. Steady-state response with direct and sinusoidal sources including analysis of polyphase circuits. One lecture hour each week will be devoted to the measurement topics of the laboratory. The laboratory provides an introduction to techniques of electrical measurements. (Prerequisite: ELE 121S corequisite: MAT 290)

ELE 211S CIRCUIT THEORY II

II-7

3 1.5 1 9

Complex frequency, network functions, poles and zeros, frequency response, the S plane. Resonance phenomena. Magnetically coupled circuits. Impedance transformations. Two-port networks. General network theorems. Transfer functions. Orthogonal functions and the Fourier series and transforms. Linear systems. Pole zero plots. (Prerequisites: ELE 210F, ELE 200F)

ELE 221S ELECTRIC AND MAGNETIC FIELDS

II-7

3 - 2 8

The physics and geometry of electromagnetic forces and fields. Field analysis and computation. Macroscopic fields in material media. Dynamics of charge particles and current carrying conduction. Lumped and distributed descriptions of electromagnetic configurations. (Prerequisites: ELE 200F, ELE 210F, MAT 290F).

ELE 231S ELECTRONIC CIRCUITS A

II-7

3 1.5 1 10

A communication system, an analog computer and digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Simple application of operational amplifiers. Qualitative description of pn junctions. Diodes and applications. Bipolar Junction Transistors: characteristics and models. Biasing of transistor circuits. Transistor amplifiers: AC coupled, DC coupled and differential. Field Effect Transistors. Transistor switching circuits. (Prerequisite: ELE 210F, Corequisite: ELE 211S)

ELE 250F ELECTRIC CIRCUITS

II-5

3 1.5 1 8.5

Circuit elements. Preliminary waveform analysis. Network equations. Solution in time-domain. Sinusoidal steady-state. Frequency-domain analysis. Complex frequency. Network functions. Frequency response, resonance. A.C. power. Polyphase circuits. Network theorems. Fourier analysis. Laplace Transforms for network transients (Fourier Transforms, Convolutions). Textbook: Strum and Ward, Electric Circuits and Networks. The laboratory will deal with the following topics: Measurement of d.c. and a.c. voltages and currents. Oscilloscopes. Analysis of periodic signals. Transients in first and second order circuits. Impedance and power measurements. (Prerequisite: ELE 150S, corequisite: MAT 295F)

ELE 270F CIRCUIT THEORY AND MEASUREMENTS

II-3

3 1.5 1.5 8

Experimental laws. Techniques of circuit analysis. Duality. Source-free RL and RC circuits. The unit-step forcing function. The sinusoidal function. Phasors. The sinusoidal steady-state response. Average power and rms values. Polyphase circuits. Magnetically-coupled circuits. Textbook: Hayt, Kemmerly, Engineering Circuit Analysis, 2nd ed. (Prerequisite: ELE 121S)

ELE 271S ELECTRICAL ENGINEERING

II-4 (elective)

3 1.5 1 8

Analysis of single phase and three-phase circuits; transformers; physical foundation of electronic devices; electronic circuits; pulse and digital circuits; electromechanical energy conversion. Textbook: Fitzgerald, Higginbotham, Grabel, Basic Electrical Engineering (Prerequisite: ELE 121S or ELE 150S or equivalent)

ELE 272S ELECTROMECHANICAL ENERGY CONVERSION

II-3

2 1.5 1.5 8

Ferromagnetism and magnetic circuits. The transformer. Principles of electromechanical energy conversion. Actuators. Steady-state operation of dc and ac machines. (Prerequisite: ELE 270F)

ELE 310F SYSTEM AND SIGNAL ANALYSIS A

III-7

3 - 2 9

System representation and analysis. Time domain analysis. Review of Fourier series, Fourier transform, and Laplace transform. A study of the behaviour of continuous-time linear systems using transform methods. Transfer functions, frequency response, Bode diagrams, energy density spectrum. Stability, Routh-Hurwitz, Nyquist, root locus. Signal flow graphs, State variable formulation. Textbook: Lathi, Signals Systems and Controls. (Prerequisite: ELE 211S)

ELE 311S SYSTEM AND SIGNAL ANALYSIS B

III-7

3 1.5 1 9

Discrete time systems, the z-transform, Convolution integral and methods, Sampling theorem, Communication systems, multiplexing, modulation, and sampling. Stochastic processes, stationarity, convolution, correlation, power spectrum, spectral analysis. Textbook: Lathi, Communication Systems; Davenport, Probability and Random Processes. (Prerequisite: ELE 310F)

ELE 312F ELECTROMECHANICAL SYSTEMS I

III-7

3 1.5 1 9

Electromechanical energy conversion principles. Magnetic circuit analysis. Modelling of linear and non-linear magnetic systems. Single phase and polyphase transformers. Transformer design. Introduction to rotating machines. Textbook: Slemon, Magneto-Electric Devices; (Prerequisite: ELE 211S, Corequisite: MEC 205F)

ELE 313S ELECTROMECHANICAL SYSTEMS II

III-7

3 1.5 1 9

Generalized approach to machines. Parameter evaluation. Steady-state and dynamic performance of DC, induction and synchronous machines. Introduction of multi-machine systems. Textbook: Slemon, Magneto-Electric Devices; (Prerequisite: ELE 312F)

ELE 314S DIGITAL SYSTEMS

III-7;III-5e(elective)

2 1.5 - 6

Introduction to logic, propositional logic, Boolean algebra, basic operations, truth tables, fundamental algebraic manipulations. Storage elements, flip-flops and registers, register transfer operations. Design of counters, encoders, decoders. Fan-in, fan-out. Number representation and coding, 1's and 2's complement, BCD, parity. Designs for adders, multipliers, dividers. Memory techniques, read/write, read only, volatile, non-volatile magnetic core memory. Design methods for control and data flow in simple systems such as sampled data communications, feedback digital controller. Textbook: Peatman, The Design of Digital Systems. (Prerequisites: ELE 201S, ELE 231S or equivalent)

ELE 320F FIELDS AND WAVES

III-7

2 1.5 1 8

Transmission line theory; Smith chart. Propagation of plane waves and their reflection at boundaries. Guided waves. Radiation from antennas. Elementary theory of interference and diffraction phenomena. Textbook: Kraus, Carver, Electromagnetics. (Prerequisite: ELE 221S)

ELE 331S ELECTRONIC CIRCUITS B

III-7

3 3 - 10

Ideal amplifiers: characterization and applications. Ideal Diodes: applications, JFET and MOSFET: mechanisms, models and applications. Biasing: passive, active and reactive loads; distortion, power dissipation. Junction diodes and transistors: properties, models and applications. Biasing: operating point stability, thermal runaway. Frequency effects; gain calculations; Miller effect. Differential amplifiers; Operational amplifiers; Multistage amplifiers; Negative feedback. Textbooks: Millman and Halkias, Integrated Electronics; Angelo, Electronics: BJT's, FET's, and Microcircuits. (Prerequisite: ELE 231S, corequisite: ELE 336S)

ELE 335F PHYSICAL ELECTRONICS A

III-7

2 .75 .75 6

Introductory quantum mechanics leading to the band theory of solids. Emission phenomena. Structure and basic properties of semiconductors. Hole and electron densities: impurities; generation and recombination processes. Carrier transport: the continuity equations. Semiconductor diodes: theoretical and practical aspects of p-n junction, metal-semiconductor and other diode types. (Prerequisites: MMS 221F, ELE 231S).

ELE 336S PHYSICAL ELECTRONICS B

III-7

2 - 1.5 6

Unipolar transistors; junction gate, M.I.S., and other surface devices: theory and circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis circuit models. PNP devices. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking; capacitors, resistors, bipolar and unipolar transistor integration. Photoelectronics, solid-state optoelectronic phenomena: photoconductive and pn junction radiation detection. Image orthicon, vidicon, image storage and intensification. (Prerequisite: ELE 335F)

ELE 350F PHYSICAL ELECTRONICS I

III-5cs,5e;5p (elective)

2 .75 1 7

Courses ELE 350F and ELE 352S deal with the basic physics underlying the operation of semiconductor devices. Band theory of solids, metals, semiconductors, insulators, mobility and conductivity. Drift and diffusion currents. Theory of pn junctions. Tunnel, avalanche and Zener diodes. Theory and operation of bipolar transistors. (Prerequisite: PHY 281S, exclusion: ELE 335F)

ELE 351F ELECTRONIC CIRCUITS I

III-5cs,5e;5g (elective); IV-5nt (elective)

2 1.5 1 8

A communication system, an analog computer and digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Ideal and real diodes with applications. Qualitative description of pn junctions. Characteristics of bipolar transistors in the normal mode. Biasing design of transistor circuits. Derivation of 1st order equivalent circuits. Design of simple transistor amplifier circuits. (Prerequisites: ELE 250F, exclusion: ELE 231S)

ELE 352S PHYSICAL ELECTRONICS II

III-5e;5p (elective)

2 .75 1 7

Small signal model, circuit configurations and applications of the bipolar transistor. Theory of junction and MOS field effect transistors; small signal models. Theory and applications of switching devices: pnpn diode, silicon-controlled rectifiers, triacs, unijunction transistor. Fundamentals of integrated circuits. (Prerequisite: ELE 350F, exclusion: ELE 336S)

ELE 353F COMPUTER ORGANIZATION

III-5cs;IV-5e (elective)

3 1.5 1 10

Digital system design principles. Registers and data flow. Computer structure, machine language instruction execution and sequencing, addressing techniques. Organization and design of central processing units. Microprogramming. Arithmetic operations. Memory hierarchy, direct and associative addressing. I/O techniques and channels. Some case studies of actual machines. Introduction to reliability. The laboratory will consist of experiments involving logic systems, and small computers, including microprocessors. (Exclusion: ELE 441S)

ELE 354S ELECTRONIC CIRCUITS II

III-5e;5g (elective)

3 3 - 10

Design of AC coupled transistor stages, DC amplifier. Integrated circuit design limitation. Design of multitransistor circuits from configuration point of view. Hybrid- Π equivalent circuit models. Design of audio amplifiers, wideband amplifiers, tuned amplifiers. Negative feedback concepts and oscillators. Field effect devices and applications. Transistors as switching elements. Design of simple logic and memory circuits. (Prerequisite: ELE 351F, exclusion: ELE 331S)

ELE 355F SYSTEM AND SIGNAL ANALYSIS I

III-5cs,5e

3 - 1 8

Signal representation by classical Fourier series and Fourier integral: orthogonality and completeness, pointwise and mean square convergence, inversion techniques, energy relations and time-bandwidth trade-off. Applications to circuits, sampling and modulation. Laplace transform: inversion techniques, application to transient analysis and frequency response of systems described by ordinary differential and differential-difference equations. Additional topics selected from: distributions, z-transform, discrete Fourier transform. (Prerequisite: ELE 250F, MAT 295F, MAT 289S, or equivalent. Most assignments require use of the computer. Exclusion: ELE 310S)

ELE 356S SYSTEM AND SIGNAL ANALYSIS II

III-5e

3 1.5 - 8

Modelling of physical systems. State representation of dynamic systems as vector matrix differential and difference equations. Linearization. Controllability and observability. Steady-state performance and stability analysis for constant, linear systems employing Bode diagrams, root loci, Routh and Nyquist criteria. Synthesis of elementary feedback compensators. (Prerequisite: ELE 355F, Exclusion: ELE 311F).

ELE 357F ELECTROMAGNETIC FIELDS

III-5e,5g,5p

3 1.5 1 9

Transmission lines. Smith chart. Maxwell's equations and constitutive relations. Plane waves in dielectric and conducting media. Wave polarization. Poynting vector. Waveguides. Retarded potentials. Small loop and short dipole antenna. (Prerequisite: ELF 221S, or PHY 280F; MAT 289S)

ELE 360S ELECTRONIC CIRCUITS II
 III-5cs;IV-5nt (elective) 3 1.5 - 8
 As prescribed for ELE 354S with special laboratory exercises.

ELE 405F SWITCHING THEORY
 IV-5cs;IV-5e,7 (elective) 2 - 2 8
 Boolean algebra, boolean functions. Design and minimization of combinational networks. Sequential machines, finite state models, synthesis, state assignment, state reduction. Synthesis and analysis of asynchronous sequential machines. Combinations of sequential machines. Identification. Textbook: Kohavi, Switching and Automata Theory. (Prerequisite: ELE 314S)

ELE 410F CONTROL SYSTEMS I
 IV-7 (elective) 2 1.5 1 8
 Review of steady-state and dynamic performance analysis, stability analysis and Bode diagrams. Linear compensation design. Process control design. Frequency and time domain analysis of nonlinear controllers; design of real control systems. (Prerequisite: ELE 311S; exclusion: ELE 450F)

ELE 411S CONTROL SYSTEMS II
 IV-7 (elective) 2 1.5 1 8
 An introduction to the design of multivariable control systems using state-space methods. Vector-matrix differential equations as models for physical systems, and their solution by analytic and computational methods. Eigenvalues, eigenvectors, and modal analysis. Controllability; design of modal controllers. Observability; design of dynamic observers. Design of industrial regulators; integral feedback and feedforward control. Design using optimal control methods (Prerequisite: ELE 410F or MEC 357S or MEC 455F; exclusion: ELE 450F)

ELE 412F NETWORK THEORY
 IV-5e,7(elective) 3 - 2 8
 Network analysis and network functions. Properties and synthesis of LC and RC one-ports. Positive real functions, testing, realizations. Properties and synthesis of lossless singly-and doubly-terminated two-ports. Approximations to ideal filters. Introduction to active or digital filters as time permits. (Prerequisite: ELE 311S, ELE 201S)

ELE 413F POWER SYSTEM ANALYSIS
 IV-7 (elective) 2 1.5 1 8
 Identification of the power system. Transmission lines, parameters and representation. Synchronous machines and other power system components. Behaviour of elementary power systems under fault conditions. Textbook: Stevenson, Elements of Power System Analysis (3rd Edition). (Prerequisite: ELE 313S)

ELE 414S POWER SYSTEM CONTROL
 IV-7 (elective) 2 1.5 1 8
 Control of power and frequency. Control of voltage and reactive power. Load flows. Stability limits. Underground transmission. Direct current transmission. Overvoltages and insulation requirements. Protection. Textbook: Weedy, Electric Power Systems, 2nd ed. (Prerequisite: ELE 413F)

ELE 416F COMMUNICATION SYSTEMS A
 IV-7 (elective) 2 3 - 8
 Spectral analysis, use of Fast Fourier Transforms for simulation, random variables and processes, AM and FM systems, vestigial side band, single side band, noise in modulation systems. Textbook: Taub and Schilling, Principles of Communication Systems. (Prerequisite: ELE 311S)

ELE 419S ELECTROMECHANICAL SYSTEMS III

IV-7 (elective)

2 1.5 1 8

Steady state and dynamic operation of both AC and DC industrial drive systems. Design of conventional and solid state control including position velocity and torque control applications. Introduction to elementary machine and machine system design. Elementary treatment of Linear Motors Systems for high speed transportation. (Prerequisite: ELE 313S, Corequisite: ELE 410F)

ELE 420F ELECTROMAGNETICS

IV-5e,7 (elective)

2 1 1 8

Basic considerations in solving field problems by such means as differential equations, graphical methods, and conformal transformations. Antenna system design. Wave propagation in anisotropic media. General analysis of guided waves. Textbook: Ramo, Whinnery and Van Duzer, Fields and Waves in Communication Electronics. (Prerequisite: ELE 320F or ELE 357F)

ELE 422S RADIO SYSTEMS

IV-7 (elective)

2 - 1 8

An introduction to systems employing radio and light waves using selected examples from the fields of communications, remote sensing, navigation and traffic control. Emphasis will be on overall objectives, physical and economic constraints, means of implementation, basic system parameters and evaluation of performance. The impact of new technology on system design will be examined. Also included will be field trips, seminars and project studies. (Prerequisite: ELE 420F).

ELE 423S HIGH-FREQUENCY ACTIVE DEVICES

IV-5e,7 (elective)

2 1.5 1 8

The purpose of the course is to introduce the theory, construction and applications of devices operating in the frequency range for which conventional electronic devices are not suitable. The following types of devices will be discussed: Gunn, IMPATT and parametric amplifiers and oscillators in the microwave and millimeter frequency ranges, and laser type devices in the infrared and optical regions. The material will include the discussion of the required background physics and the limitations of the apparatus considered. (Prerequisites: ELE 420F/ELE 448F/ELE 357F. Exclusion: ELE 414S).

ELE 430F ELECTRONIC CIRCUITS C

IV-7 (elective)

2 3 - 8

A course on the analysis and design of analog circuits. Modern biasing techniques, differential amplifiers. Design of multistage DC amplifiers. Operational amplifiers. Stability of feedback amplifiers. Active-RC filters. Oscillators. Wide band amplifiers. Tuned amplifiers. Power amplifiers. Modulators, demodulators, analog multipliers and phase-lock loops. (Prerequisite: ELE 313S and ELE 311S)

ELE 431S INTEGRATED CIRCUITS

IV-7,5e (elective)

2 3 - 8

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Linear integrated circuit design techniques and limitations. Digital integrated circuits design evolution leading to large scale integration. (Prerequisite for IV-7: ELE 336S, ELE 331S; for IV-5e: ELE 352S, ELE 354S)

ELE 432S SWITCHING CIRCUITS

IV-5cs;IV-5e,7 (elective)

2 3 - 8

A design course in electronic switching circuits. Static and dynamic characteristics of semiconductor devices as switching elements. Transistor multivibrators. Integrated circuit logic families. Linear and non-linear waveshaping techniques. Digital to analogue and analogue to digital conversion. Memory technology. (Prerequisite for IV-7: ELE 314S, ELE 331S; for IV-5: ELE 354S, ELE 314S)

ELE 433F POWER SEMICONDUCTOR CIRCUITS

IV-7,5e (elective)

2 3 - 8

Circuits with switches and diodes, power semiconductor switches. Specifications of thyristor or silicon controlled rectifier, AC voltage controllers, controlled rectifiers, DC to DC converters, inverters, applications to motor control, logic and control circuits. Textbook: Dewan and Straughen, Power Semiconductor Circuits. (Prerequisite ELE 331S, ELE 314S)

ELE 435F SEMICONDUCTOR ELECTRONICS

IV-7,5e (elective)

2 1.5 1 8

This course is concerned with certain theoretical and practical aspects of semiconductor devices. Electron dynamics in the crystal lattice distribution of carriers and properties of excess carriers will be discussed. P-n junctions, light emitting diodes, Gunn diodes, SCRs and other devices will be considered. Textbook: R.A. Holmes, Physical Principles of Solid State Devices. (Prerequisites: ELE 336S or ELE 352S)

ELE 440F COMPUTER SOFTWARE ENGINEERING I

IV-7,5e (elective)

2 - 2 8

This course is an introduction to computer system software engineering. Topics will include: Effective programming practice Overview of machine structure and machine language; Data structures, including searching and sorting; High level language concepts, an introduction to formal grammars, and the design of language processors (Prerequisite: ELE 314S or equivalent; Exclusion: CSC 380S)

ELE 441S COMPUTER ORGANIZATION

IV-7,5e (elective)

2 3 - 8

The design of digital computers including the following topics: Control unit organization; series-parallel operation, control unit logic, microprogrammed control. Arithmetic units: addition, subtraction, multiplication, division, floating point arithmetic. Storage systems: core memory. I/O: I/O organization, interrupts. Highly parallel systems: pipeline systems, array processors. (Prerequisite: ELE 314S, exclusion: ELE 353F)

ELE 442S COMPUTER SOFTWARE ENGINEERING II

IV-7

3 1.5 - 8

This course is a second-level treatment of some of the material introduced in ELE 440F Computer Software Engineering I. Topics will include the theory, detailed design, and implementation of language processors, including the effect of various language constructs and machine structures; and the principles and design of operating systems and data management systems. (Prerequisite: ELE 440F or equivalent, exclusions: CSC 380S, CSC 468F)

ELE 445S BIOMEDICAL ENGINEERING

IV-7, 5e (elective)

3 1.5 - 8

An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Engineering: Basic physiology and anatomy, Biological communications processes, Nuclear medical engineering and radiation physics, Chemical aspects of Biomedical Engineering, Bioengineering in physiology. The laboratory gives the student the opportunity to measure physiological parameters and to use ultrasonic and nuclear devices. Opportunity will also be provided for the observation of surgical and other techniques. Textbook: Selkurt, Physiology; or McNaught, Callander, Illustrated Physiology. (Prerequisite: ELE 331S and ELE 310F or equivalent)

ELE 447S ILLUMINATION

IV-7 (elective)

3 1.5 - 8

The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: the nature and characteristics of light; the production of light: incandescence and luminescence; the human eye, visual processes, and visual phenomena; radiometric and photometric units and laws; photometric measurements; calculation of photometric quantities; design of the visual environment: principles which relate to visual comfort and efficiency; colour and colorimetry; light sources - circuits and controls; visual problems at low light levels e.g. street lighting. Textbook: Stevens, Building Physics-Lighting.

ELE 448F APPLIED OPTICS

IV-7 (elective)

2 1.5 1 8

Principles of ray optics and their applications to the design and analysis of optical systems including the theory of aberrations. Wave optics of isotropic and anisotropic media, interference phenomena and diffraction limits of optical systems. Textbook: M.V. Klein, Optics. (Prerequisite: ELE 320F)

ELE 449F ENGINEERING AS A PROFESSION

IV-7 (elective)

2 - - 8

The course will consist of a combination of lectures and seminars on the role of the Engineer in society. Topics to be discussed include: 1. Why does society not yet consider the engineer to be fully professional? 2. Does the engineer have a proper set of values? 3. Why does there not exist a philosophy of engineering? 4. Should the engineer bear the sole responsibility for the social consequences of his engineering projects? 5. What is the role of the engineer in such public issues as pollution, unemployment, urban development, etc. 6. The role of the engineer as an entrepreneur.

ELE 452F ELECTRONIC CIRCUITS III

IV-5e (elective)

2 3 - 8

A design course in electronic circuits including: Multistage amplifiers. Feedback amplifiers. Oscillators. Wideband amplifiers. Tuned amplifiers. Low noise amplifiers. Power amplifiers. Active filters. Use of functional electronic building blocks, e.g., operational amplifiers, multipliers, phase locked loops, etc., in instrumentation applications. Computer aided circuit design is used throughout the course. (Prerequisite: ELE 352S, ELE 354S, exclusion: ELE 430F)

- ELE 453F COMMUNICATION SYSTEMS I
IV-5cs;5e (elective) 2 3 - 8
Spectral analysis, Use of the Fast Fourier Transform, AM and FM systems, Pulse and Pulse code modulation; Random processes and noise in communication systems. The laboratory includes both computer problems involving the FFT, measurements on various modulation systems (AM, SSB, FM, PCM), and demonstrations. Text Book: Taub and Schilling, Principles of Communications Systems. (Prerequisite ELE 355F; Exclusion ELE 416F).
- ELE 454S COMMUNICATION SYSTEMS II
IV-5cs;5e,7 (elective) 2 3 - 8
Noise in communication systems. Performance of AM and FM systems. The threshold effect in FM systems. Phase locked loops. Introduction to coding. (Prerequisite: ELE 416F or ELE 453F).
- ELE 455S TECHNIQUES OF OPTIMIZATION
IV-5cs;5e (elective) 3 - 1 8
Calculus of variations. Maximum Principle. Linear and non-linear mathematical programming; dynamic programming; some problems in control theory; Applications will be drawn from engineering practice. (Prerequisite: APM 393F)
- ELE 470F ELECTRICAL SYSTEMS
IV-8 3 3 - 9
Electrical circuits, components, machines, sensors, transducers, instrumentation and controls with emphasis on practical applications, including heating and melting. Textbook: Lister, Electric Circuits and Machines(5 th ed.).
- ELE 471F INSTRUMENTATION DESIGN
IV-3 (elective) 2 1.5 - 8
This course includes the theory, methods, and instrumentation required for the measurement of variables of interest to mechanical engineers;e.g., strain, liquid flow, air-flow, vibration, etc. Also included is a discussion of transducers required to convert these variables to electrical signals, and the use of electronic modules in the design of equipment to process these signals. The interfacing of these modules with analogue and digital recording and processing devices will also be covered.
- ELE 496F THESIS
IV-7 - - - 16
Each student in Electrical Engineering is required to write a thesis on an approved topic of his choice under the supervision of an academic staff member of the department. The thesis may involve experimental or other project-related activities. The weight to be attached to the thesis depends on the size of the thesis topic and must be approved by the student's thesis supervisor. The topic selected must be registered with the IV year thesis coordinator within two weeks of the beginning of term. Further details are available from the Electrical Engineering Enquiry Office, G.146. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 497S, ELE 498F, ELE 499S)
- ELE 497S THESIS
IV-7 - - - 16
Same as ELE 496F, but in spring term. (Prerequisite: completion of all third year technical courses, Exclusions: ELE 496F, ELE 498F, ELE 499S)
- ELE 498F THESIS
IV-7 - - - 8
Same as ELE 496F, but of smaller weight. (Prerequisite: completion of all third year technical courses, exclusions: ELE 496F, ELE 497S)

ELE 499S THESIS

IV-7

- - - 8

Same as ELE 498F but in spring term. (Prerequisite: completion of all third year technical courses. Exclusions: ELE 496F, ELE 497S)

DEPARTMENT OF ENGLISH

Students' attention is also drawn to English offerings in the Faculty of Arts and Science. Full-year courses corresponding to the one-term courses listed below are: ENG 108Y FORMS OF TWENTIETH-CENTURY LITERATURE; ENG 152Y CANADIAN LITERATURE IN ENGLISH. See also: ENG 112Y MAJOR BRITISH WRITERS; ENG 140Y POETRY; ENG 150Y AMERICAN LITERATURE; ENG 165Y ENGLISH LITERATURE: FORMS AND APPROACHES. Students without the required pre- or co-requisite (one full-year course in English) may petition for admission to 200-series courses such as ENG 220Y VARIETIES OF PROSE FICTION, ENG 230Y VARIETIES OF DRAMA, and ENG 270F/S SPECIAL STUDIES.

ENG 281F/S EFFECTIVE WRITING

2 - - 8

This course is concerned with general problems of effective writing and with the proper use of language in prose composition. An "effective" writer knows how to express his ideas clearly and precisely, how to employ the laws of logic in ordering and supporting an argument, and how to use language persuasively. Classwork will involve discussion of the theory and method of various kinds of writing, supplemented by close consideration of examples of effective prose, but the main emphasis of the course is on frequent and varied practical exercises designed to develop writing technique. Enrolling students should have basic writing skills. Text: Strunk and White, *Elements of Style*.

ENG 282F/S TWENTIETH-CENTURY LITERATURE I

2 - - 8

This course provides an introduction to prose fiction, drama, and poetry written in English during the twentieth century. Representative works of at least eight major authors will be studied, including: Conrad, *Lord Jim*; Lawrence, *Sons and Lovers*; Faulkner, *As I Lay Dying*; O'Neill, *Long Day's Journey into Night*; Yeats, *Selected Poems*, ed. A. Norman Jeffares.

ENG 283F/S CANADIAN LITERATURE I

2 - - 8

This course will deal with representative works of at least eight Canadian writers, and will consider some of the historical and cultural influences upon the development of Canadian writing. Texts studied will include: Laurence, *The Stone Angel*; Richler, *The Apprenticeship of Duddy Kravitz*; Davies, *Fifth Business*; Ryga, *The Ecstasy of Rita Joe*; *Poetry of Mid-Century, 1940/1960*, ed. Milton Wilson (NCL).

ENG 284F/S VARIETIES OF FICTION I

2 - - 8

This course is designed to increase enjoyment and understanding of various forms of prose fiction through close consideration of at least eight representative works written in English, including: Bacon, *New Atlantis*, ed. Harold Osborn; Defoe, *Moll Flanders*; Dickens, *Hard Times*; Twain, *Huckleberry Finn*; Lawrence, *The Rainbow*.

ENG 285F/S DRAMA AND THE MODERN THEATRE I

2 - - 8

This course is designed to increase understanding and enjoyment of drama. It will deal with plays (of whatever period) which are still being performed in the contemporary theatre and will consider the reasons for their theatrical effectiveness for modern audiences. Where possible, attention will be given to filmed drama and to plays currently being performed in Toronto.

ENG 286F/S LITERATURE AND SCIENCE I

2 - - 8

This course will explore some of the ways in which the methods and discoveries of science have made and are making an impact upon literature and will deal with at least eight significant works which were written in response to the scientific and technological ideas of their time. Works studied will include: Shakespeare, The Tempest; Swift, Gulliver's Travels; Mary Shelley, Frankenstein; Wells, The Time Machine; Huxley, Brave New World.

ENG 292S TWENTIETH CENTURY LITERATURE II

2 - - 8

Continuation of ENG 282F (Prerequisite ENG 282F/S)

ENG 293S CANADIAN LITERATURE II

2 - - 8

Continuation of ENG 283S (Prerequisite ENG 283F/S)

ENG 294S VARIETIES OF FICTION II

2 - - 8

Continuation of ENG 284F (Prerequisite ENG 284F/S)

ENG 295S DRAMA AND MODERN THEATRE II

2 - - 8

Continuation of ENG 285F (Prerequisite ENG 285F/S)

ENG 296S LITERATURE AND SCIENCE II

2 - - 8

Continuation of ENG 286F (Prerequisite ENG 286F/S)

DIVISION OF ENGINEERING SCIENCE

ESC 495Y,498F,498S,499Y THESIS

IV-5

Every student in Fourth Year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the Spring Term of Third Year, and copies may be obtained in the division office. The weight allocated in each term of each option is shown in the Fourth Year curriculum. The full year theses will be graded after submission in the Spring term, and the grade included in the weighted average for that term only. The weight assigned will be the sum of the weights for both terms. A design project as described under CED 401Y may be undertaken in lieu of thesis.

DIVISION OF GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

GLE 201S TOPICS IN GEOLOGICAL ENGINEERING

II-2

2 - 2 7

A survey course to acquaint students with engineering problems and their solution in areas of the three options in the program and to inform the student of the type of engineering in which they might be engaged in professional practice. The time in the course is divided equally among the Department of Geology, the Department of Metallurgy and Material Science, and the Department of Civil Engineering.

Co-ordinator: F.A. De Lory

GLE 301F PLANNING AND MANAGEMENT OF MINERAL EXPLORATION I

III-2A,2B

3 - 1 8

This course, in conjunction with GLE 302S is a basic course in the essentials of planning, management, and economics of mineral exploration, development and production. It is directed to those students who may decide on a career in the mineral industry. The course will include a historical review and role of exploration; organization, administration, management and supervision of mineral exploration; financing, budgeting and expenditures of mineral exploration; legal aspects of property acquisition; exploration philosophy, political, economics; metallogeny; selection of areas and methods; property evaluation; planning and logistics of exploration; selection of geological, geochemical, and geophysical methods. Case History studies. Prerequisites: GLG 120/180S, GLG 220

GLE 302S PLANNING AND MANAGEMENT OF MINERAL EXPLORATION II

III-2A,2B:

3 - 1 8

This course is a continuation of GLE 301F and will include discussions of diamond drilling, contracting, methods, choice of equipment evaluation of data, decision making, feasibility studies, production decision, financing, development, choice of mining methods, mine management, ore reserves, sampling procedures, grade control, mining geology, and Case History studies. GLE 301F and GLE 302S will take the student through the programming and critical path of exploration projects from from prospecting to production decisions. The course will be supplemented by visits to various exploration departments of mining companies and will be augmented by speakers who are specialists in their particular disciplines. Much emphasis will be placed on Case History studies. Prerequisite: GLE 301F

GLE 401F ECONOMICS OF MINERAL RESOURCES

IV-2A, 2B

3 - 1 8

The application of basic economics to mineral resources and the mineral industry including specific examples of supply and demand and consideration of mineral policy, mineral trading, taxation, government policy and environmental protection.

Every student in fourth year Geological Engineering and Applied Earth Science is required to prepare a thesis on an approved subject. The Option A thesis (GLE 492S) is a Spring Term thesis and topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. For Option B, the thesis will normally involve experimental as well as other project related activities and will generally be done throughout both Fall and Spring terms. A shorter one-term thesis (GLE 494S) may be selected with the approval of the thesis supervisor. For Option C the thesis is normally a Spring Term thesis (GLE 496S) with the topic submitted for approval in the fall term and the work done in the Spring Term under the supervision of a faculty member. With the permission of the Chairman of the Division a 16 unit thesis extending through both terms (GLE 495) may be taken.

DEPARTMENT OF GEOLOGY

GLG 180S APPLIED PHYSICAL GEOLOGY

I-1,2,3,4,5,6,7,8 (elective)

3 1.5 - 8

Fundamentals of physical geology as related to engineering problems and practice. Configuration of the planet and the effects of external and internal processes that act upon it; influence of earth processes as a factor in the design of engineering structures. Students will gain a knowledge of earth materials, their occurrence and uses. Textbook: Flint & Skinner, Physical Geology (Exclusion: GLG 120C, GLG 280S)

S.D. Scott, A.J. Naldrett

GLG 181F PRINCIPLES OF PHYSICAL GEOLOGY

III-5g;II-2 (elective)

2 2 1 9

Principles of physical geology and the evolution of the earth as a planet. Topics include the composition and form of minerals and rock bodies, the deposition of sediments by rivers and oceans, the origin of mountain systems and the development of global structures. Air photographs, geological maps and cross sections are used in studying the effects of geologic processes. A field trip is taken in October. (Exclusions GLG 120C, 180S)

E.W. Nuffield

GLG 182S PRINCIPLES OF HISTORICAL GEOLOGY

II-2,III-5g

2 2 1 9

A lecture-laboratory course that traces the history of the earth and its changing environment from the sequence of physical and biological events revealed in the rock record. Paleontology and concepts of geologic environments and time are emphasized in the laboratory and in the field. (Prerequisite: GLG 180S or 181F; Eclusion: GLG 120D)

R. Ludvigsen

GLG 220Y INTRODUCTORY MINERALOGY AND PETROLOGY

II-2;III 5g (elective)

2 3 - 9,2 3 - 9

In the fall term, mineralogical concepts, optical mineralogy and important rock and ore forming minerals are reviewed. The spring term gives an introduction to the classification, occurrence and genetic processes of igneous, metamorphic and sedimentary rocks. Laboratories include crystallographic exercises, mineral optics, and the study of rocks and minerals in the microscope and hand specimen.

J.C. Rucklidge, A.M. Goodwin

GLG 280S APPLIED PHYSICAL GEOLOGY

II-I (elective)

2 1.5 1 8

A course similar to GLG 180S, but with alternate laboratory assignments.

A.M. Goodwin

GLG 315F FIELD TRIP

II-2

- - - 6

A field course that must be taken by all student in Geological Engineering and Applied Earth Science. This is an 8 day field trip either in the Huronian sedimentary suite of the Elliot Lake-Sudbury area or the Northern Appalachians of the Lower St. Lawrence which empahsizes elementary mapping methods and basic field techniques applicable to structuralstratigraphic-mineral deposit studies. A fee, currently \$60, is charged to cover part of the cost of transportation and accommodation.

GLG 320Y PETROLOGY

III-2A,B

2 3 - 8, 2 3 - 8

The principles of igneous, sedimentary and metamorphic petrology with major emphasis on examination of criteria used for the classification of the major rock types: The interpretation of rocks as indicators of crustal and mantle process. Laboratory work covers the use of hand specimen and thin section techniques in the description and identification of rocks and the preparation of petrographic reports for problems in applied geology related to mineral exploration, mineral extraction, rock mechanics and geotechnical engineering. (Prerequisite: GLG 220)

J.J. Fawcett

GLG 321F STRATIGRAPHY AND SEDIMENTATION

III-2A,2C

1 3 - 8

The properties and classification of sediments and strata. Sedimentary environments and tectono-environmental concepts in stratigraphy; the influence of global tectonics on local stratigraphy. Stratigraphy applied to mineral exploration. (Prerequisite: GLG 220, GLG 120D)

F.W. Beales, J.B. Currie

GLG 322Y TECTONICS

III-2A,2C

1 3 - 8, 1 3 - 8

Geometry of existing deformational structures in the earth's crust and reconstruction of their mechanical development. Application of rock mechanics to interpretation of geologic structures. Laboratory work emphasizes methods of structural analysis. (Prerequisite: GLG 220, corequisite: GLG 321F)

W.M. Schwerdtner

GLG 327S PRINCIPLES OF PRECAMBRIAN GEOLOGY

III-2A

2 2 - 8

The stratigraphy, tectonic divisions and economic aspects of the Precambrian. Laboratory study of geological maps and reports; examination of typical rock suites in hand specimens and thin sections. (Prerequisite: GLG 321F, corequisite: GLG 322)

A.M. Goodwin

GLG 330F PHASE DIAGRAMS FOR GEOLOGISTS

III-2A

3 - - 8

Principles of phase equilibrium as applied to multicomponent silicate, sulphide and oxide systems over a wide range of temperatures and pressures of geological interest.

S.D. Scott

GLG 331S INTRODUCTION TO GEOCHEMISTRY

III-2A

3 - - 8

Chemical aspects of geological processes, at and beneath the earth's surface. Textbook: Krauskopf. (Prerequisite: CHM 100F)

G.M. Anderson

GLG 415F FIELD COURSE II

IV-2B

- - - 4

A one week field camp for students in Option B, held in the Tweed, Ontario area immediately following the conclusion of the annual Third Year examinations. Instruction and experience in geological mapping. A fee, currently about \$60.00 is charged to cover part of the costs of meals and accommodation. (Prerequisite: GLG 220, GLG 320)

GLG 416F FIELD COURSE

IV-2C

- - - 8

A two week Field Camp immediately following the conclusion of the annual third year examinations. The first week is in the Toronto area and will include field observation and practice in geotechnical engineering and surveying. The second week will be instruction and experience in geological mapping. A fee currently about \$60.00 is charged to cover part of the cost of food and accommodation for the second week.

GLG 421Y APPLIED MINERAL DEPOSITS GEOLOGY

IV-2A

2 3 - 8, 2 3 - 8

Lectures stress descriptions of important deposits and their geological setting; discussion of ore forming processes, including the application of geochemistry to ore genesis; systematic ore mineralogy. Laboratories are concerned with the identification of ore minerals in polished section using the ore microscope, reflectivity and microhardness equipment, and x-ray powder diffraction. Numerous ore suites are examined and one suite, selected by the student, is studied in detail: all studies of ore suites are oriented towards the problems of milling the ore and the types of concentrates that are likely to be produced.

A.J. Naldrett

GLG 422Y ORE MINERAL IDENTIFICATION

IV-2B

- 3 - 4, - 3 - 4

The laboratory portion of GLG 421.

GLG 425F FIELD CAMP

IV-2A

- - - 8

A two-week field camp for students in Option A immediately following the conclusion of the annual Third Year examinations. Instruction and experience in geological mapping. A fee, currently \$100.00, is charged to cover part of the costs of meals and accommodation. (Prerequisite: GLG 320, 322)

GLG 428F PETROLEUM GEOLOGY AND ENERGY RESOURCES

IV-2A

2 3 - 8

Application of geology to exploration for oil and gas and to evaluation of other energy sources within sedimentary basins, namely coal and uranium. Analysis of conditions that influence the use of non-renewable energy resources.

J.B. Currie

GLG 480Y EXPLORATION GEOCHEMISTRY

IV-2A

2 3 - 8, 2 3 - 8

Geochemical aspects of mineral exploration, including characterization of target, nature of detectable halos associated with target and typical survey methods. Laboratory study includes field examination of an undeveloped mineral deposit, chemical analysis of materials collected and statistical analysis of the analytical results.

S.E. Kesler, J.C. Van Loon

INSTITUTE FOR THE HISTORY AND PHILOSOPHY OF SCIENCE AND TECHNOLOGY

HPS 280F HISTORY OF SCIENCE

1 - 1 8

An introduction to the history of science, using case studies of the works of such men as Galileo, Newton, and Faraday to illustrate the development of scientific thought and its historical significance.

HPS 281F HISTORY OF TECHNOLOGY AND ENGINEERING UP TO THE INDUSTRIAL REVOLUTION

1 - 1 8

A treatment of the origins of technology and engineering covering development in the civilizations of the Ancient World, that of Greece and Rome, the Medieval World and the period of the Renaissance. Emphasis will be placed on the developments of techniques and of machines with an indication of the context in which these occur.

HPS 282S HISTORY OF TECHNOLOGY AND ENGINEERING FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT

1 - 1 8

A treatment of the development of machines and the utilization of new power sources during the period under discussion. The interrelation of new techniques and chemical processes with economic and other factors as well as the interaction between science and technology will be included.

HPS 283S TECHNOLOGY, ENGINEERING AND SOCIETY

1 - 1 8

A social history course which emphasizes the period since the Industrial Revolution. Lectures and readings concentrate on the cultural impact of technology and deal with such topics as technology and democracy, the engineering profession, and the role of government in fostering or controlling technical development.

HPS 480F SEMINAR ON THE EVOLUTION OF TECHNOLOGY

1 - 2 8

The purpose of the seminar is to probe, by means of historical case-studies, some facets of the context and consequences of technological change. Case-studies will be selected with reference to such themes as the relations between science, engineering and technology, technology and the extension of human capability through symbolic systems and machine making; technology and perceptions of technology. The seminar will meet weekly for discussion and case-study investigations. The course is primarily intended for Fourth Year students, but Third Year students may be accepted if places are available. The enrollment limit is 30 students.

DEPARTMENT OF INDUSTRIAL ENGINEERING

IND 200F ELEMENTS OF INDUSTRIAL ENGINEERING I

II-4

2 - 2 8

History of Industrial Engineering. The nature and major components of modern Industrial Engineering. The scientific method - the concepts of induction and deduction. Introduction to management science with special reference to the conceptualization of systems of men and machines, decision-making, criteria of performance, and optimization. The mathematical model and its central role - the classification and utilization of models. Basic characteristics of control systems. The formulation and structuring of typical Industrial Engineering problems.

J.W. Abrams and Staff in Industrial Engineering

IND 201S ELEMENTS OF INDUSTRIAL ENGINEERING II

II-4

2 - 2 8

A broad survey of the principles of productivity management including methods study and work simplification, plant location and facilities planning, value analysis, work measurement, production and inventory control, quality control, resources management and organization theories.

J. Rives

IND 202F COMPUTERS AND PROGRAMMING I

II-4

2 - 2 8

Computer organization; machine and assembly language; basic data structures and their applications; fundamental algorithms, computer system architecture; computer program engineering. The course emphasizes the formulation of complete, correct, and efficient algorithms for the solution of problems drawn from engineering, computer science, information processing and operational research. Practical work includes laboratory exercises and program design assignments, involving coding in /370 Assembler and PL/1.

R.W.P. Anderson

IND 203S COMPUTERS AND PROGRAMMING II

II-4

2 - 2 8

A continuation of course IND 202F with further emphasis on computer program engineering, covering the following topics: information storage and retrieval, file organization, input/output processing; data structures, list processing; introduction to functions and facilities of operating systems with specific reference to System/370; efficiency; special purpose languages. Problems chosen from engineering, operational research, and data processing, will involve coding in PL/1 and assembler. (Prerequisite: IND 202F or equivalent)

R.W.P. Anderson

IND 301F OPERATIONAL RESEARCH I

III-4

1 - 2 8

An introduction, using simplified case studies, to the methodology, techniques and applications of operational research. Emphasis will be placed on developing an understanding of operational research as a rational approach to decision-making. Models to be studied will include ones for decision-making regarding inventory, replacement, allocation, scheduling and project management. The course is presented in a self-paced modular format, without formal lectures. (Prerequisites: MAT 294S, STA 282S/STA 292S, exclusion: IND 331S)

A.A. Cunningham

IND 302S OPERATIONAL RESEARCH II

III-4

2 - 2 8

A continuation of IND 301F with emphasis on problems where more complex models are required. The focus is on the constructive interaction between problem identification and mathematical solution techniques. Models discussed include multi-period and multi-item inventory management, decision analysis, integer programming and dynamic programming. (Prerequisite: IND 301F, exclusion: IND 331S)

J.S. Rogers

IND 304F INDUSTRIAL RELATIONS

III-4 (elective)

2 - 1 8

A discussion of trade unions, labour legislation and the collective bargaining process. (Exclusion: Eco 244Y)

A. Kruger

IND 305S HUMAN FACTORS IN MAN-MACHINE SYSTEMS

III-4

2 3 - 8

The course will be concerned with Human Factors from two points of view: (a) the anatomical, physiological and psycho-physical factors underlying the design of specific man-machine interfaces in specific environments; (b) the psychological factors involved in the determination of the allocation of function between men and machines in the overall system, specifically information processing capacity, acquisition and retention of skill, adaptability and stress. The laboratory period will illustrate and emphasize experimental methods in these areas.

P.J. Foley, J. Senders

IND 306F APPLIED STATISTICAL ANALYSIS

III-4

2 - 2 8

A selection of advanced topics in applied statistics including general regression theory, analysis of variance, and design of industrial and engineering experiments. Applications to cost and productivity analysis, validation of mathematical models, design of experiments in simulation, ergonomics etc. Particular attention will be paid to real situations in which the usual assumptions of statistical theory do not hold.

J.G.C. Templeton

IND 307S FUNDAMENTALS OF PRODUCTION

III-4

2 - 2 8

The meaning of production. The economist's and engineer's approach to production; the systems approach. Production as materials processing and information processing. Characteristics of production operations: their energy, space, material yield, environmental, control and scale implications. Classification and analysis of production operations: changes in form, physical and chemical properties, location, measurement. Integration of operations and interfaces between them. Examples from various industries; influence of the production process on industry structure.

J.A. Buzacott

IND 308F UTILIZATION OF ENERGY

III-4

2 - 2 8

Sources and utilization of energy; energy storage and transport; principles of energy conversion. Economic, environmental and biological issues. The course will provide the foundations for the understanding of energy production and utilization factors in complex socio-technical systems, with special reference to production systems and related industrial and commercial operations.

J.S. Rogers, R.W.P. Anderson, E.E. Pickett

IND 331S OPERATIONAL RESEARCH

III-5cs;IV-5e (elective)

2 - 2 7

Processes of model building and solution. Problems of reliability, allocation, queueing, competition, sequencing, and co-ordination. Mathematical techniques of linear and dynamic programming, branch and bound methods, activity networks, and Markov processes. (Prerequisites: APM 281F/386S/481F; MAT 295F/290F/294S/MEC 261F; STA 287S/282S/292S/CHE 305F. Exclusions: IND 301F, 302S)

A.A. Cunninghamham

IND 412S ORGANIZATIONAL BEHAVIOUR

IV-4 (elective)

2 1 - 8

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and the implementation of change. Enrolment limited.

E. Vitalis

IND 413F FUNDAMENTALS OF MANAGEMENT SCIENCE

IV-4 (elective)

2 - 1.5 8

The course presents the basic principles of decision-making. It includes such concepts as the changing value of money, the analysis of data by Bayesian inference, the value of accurate information, the use of cardinal utility to represent aversion to risk, and the expression of individual choice by indifference curves. The concepts are illustrated with industrial applications. (Prerequisite: IND 302S)

J.W. Abrams

IND 414S APPLICATIONS OF MANAGEMENT SCIENCE

IV-4 (elective)

2 - 1.5 8

Algebraic procedures are presented for applying decision theory to processes where uncertainty is characterized by binomial, Poisson and normal distributions. Examples include inspection sampling, equipment replacement, marketing and project cost estimation. (Prerequisite: IND 413F)

R. Seal

IND 415F PRODUCTION SYSTEMS

IV-4 (elective)

2 - 1.5 8

Introduction to the basic features of production systems and methods of modelling their operation; the material flow, information and control systems. Forecasting, inventories, service level and its measurement, periodic and continuous review inventory models, ABC analysis, aggregate inventory models. The role of inventories in physical distribution. Inventories in manufacturing; requirements planning vs order point control. Planning production capacity. Production control and scheduling. Theory and simulation studies in scheduling. (Prerequisite: IND 301F)

J.A. Buzacott

IND 416F SCHEDULING AND CONTROL

IV-4 (elective)

2 - 1.5 8

Methods of design for operation and control in man-machine systems. Macro-scheduling of manpower and production with discrete and continuous models. Micro-scheduling of jobs and machines. Flow and job shop scheduling. Requirements planning. Demand forecasting and parts explosion for the levels of production. (Prerequisites: IND 302S, 203S/ 303S)

I.B. Turksen

IND 417F STOCHASTIC MODELS

IV-4 (elective)

2 - 1.5 8

A course on the analysis of stochastic models in operational research. Review of relevant aspects of probability theory; Poisson processes and renewal processes; queueing models and Markov chains; applications to problems in electronic testing, traffic flows, reliability, inventory, etc. (Prerequisites: IND 302S)

M.J.M. Posner

IND 418F SYSTEM SIMULATION

IV-4 (elective)

2 - 1.5 8

Computer simulation of systems. Design of continuous and discrete simulation models. Statistical foundations and methodology. Generation of random variates. Design of simulation experiments. Simulation programming languages. Applications: the analysis and design of systems for production, distribution, health care, education, and information. (Prerequisites: IND 302S, 203S/ 303S)

I.B. Turksen

IND 419S INFORMATION AND OPTIMIZATION

IV-4 (elective)

2 - 1.5 8

Efficient transmission of information, coding of messages, capacity of an information channel, error-correcting codes; applications to practical communication systems. Unconstrained optimization in n dimensions: classical and modern algorithms; applications to non-linear programming. (Prerequisite: CSC 381F)

J.G.C. Templeton

IND 420S MATHEMATICAL PROGRAMMING

IV-4 (elective)

2 - 1.5 8

Formulation of the linear programming problem, the simplex method (review), the revised simplex method, duality and the dual simplex method, postoptimality problems, parametric linear programming. Transportation problems, the fixed charge problem. Flows in networks. Integer linear programming, algorithms for the all-integer and the mixed integer-continuous problem. Fractional linear programming. (Prerequisite: IND 302S)

J. Abraham

IND 421S MANAGEMENT INFORMATION SYSTEMS

IV-4 (elective)

2 - 1.5 8

Study of information systems in relation to both operational and decision-making activities in an organization; special attention to management planning and control activities. Models of information systems; manpower, logistics, and financial subsystems. Integrated systems. The roles of the information analyst and systems designer; the information processing organization; user implications. The development cycle of information processing systems; project control, implementation, and evaluation. Case studies and projects. (Prerequisite: IND 203S)

S.H. Cohn

IND 423F HUMAN PERFORMANCE IN MAN-MACHINE SYSTEMS

IV-4 (elective)

2 3 - 8

The course will cover theoretical and empirical aspects of human performance capabilities in information processing, decision making and control processes, and the loads imposed on the human operator by such tasks. The laboratory will stress the testing and validation of theories and models of human performance and work load measurement. (Prerequisite: IND 305S)

J. Senders

IND 424S HUMAN INFORMATION PROCESSING IN MAN-MACHINE SYSTEMS

IV-4 (elective)

2 3 - 8

An examination of Human Information Processing, with particular attention to the nature of biological coding mechanisms; the organization of sensory and perceptual processes; attention and vigilance; the structure and functional limitations of symbolic processes and language. (Prerequisite: IND 305S)

P.J. Foley

IND 425S DYNAMICS OF GENERAL SYSTEMS

IV-4 (elective)

2 - 1.5 8

Development of dynamic models using state space representation for planning and control of industrial, environmental, economic, and social processes. Parameter identification and control methods will be used to study the implications of growth, stability, productivity, energy transfer, and community organization on such systems along with certain topics in population dynamics and adaptive control mechanisms in changing environments. (Prerequisites: MAT 294S, MEC 357S, recommended: APM 391F)

E. E. Pickett

IND 426S ORGANIZATIONAL BEHAVIOUR

IV-1,2,3,5,6,7,8 (elective)

- 5 - 8

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and implementation of change. The laboratory will emphasize the interaction among people in problem-solving situations, while performing the dual role of employee/professional. Enrolment is limited. (Exclusion: IND 412S)

R.C. Whitney

IND 499Y THESIS

IV-4 (elective)

- 6 - 8, - 6 - 8

Design and analysis of an engineering system to satisfy specified objectives and requirements. This project, extending over two terms, will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in his other Industrial Engineering subjects. The work will be carried out by students working in small groups, or individually, under the supervision of staff members.

Staff in Industrial Engineering

DEPARTMENT OF MATHEMATICS

MAT 185S LINEAR ALGEBRA

I-5

2 - 1 8

Matrix algebra, applications to network problems. Gauss-Jordan method for solving simultaneous linear equations. The rank of a rectangular matrix, the dimension of the vector space of solutions to a homogeneous equation, and the existence and uniqueness of solutions to simultaneous linear equations. Geometric properties of 2×2 determinants, definition and basic properties of $n \times n$ determinants, Cramer's Rule. Eigenvalues and eigenvectors with application to vibration problems and the simplification of quadratic forms.

MAT 186F CALCULUS I

I-1,2,3,4,6,7,8

2 - 2 6

Limits, differentiation, maximum and minimum problems, definite and indefinite integrals, fundamental theorem, areas, volumes, approximation techniques.

MAT 187S CALCULUS II

I-1,2,3,4,6,7,8

2 - 2 7

Applications of integration including moments, pressure and work, elementary functions, techniques of integration, vector differentiation, series, differential equations.

MAT 188F Algebra I

I-1,2,3,4,6,7,8

2 - 2 6

Linearity, vectors, complex numbers, linear transformations, matrices, determinants, inverse of a matrix, scalar product.

MAT 189S ALGEBRA II

I-1,2,3,4,6,7,8

2 - 2 6

Quadratic forms, orthogonal transformations, eigenvalues, eigenvectors geometry of lines and planes, linear programming.

Staff in Mathematics and Staff in Engineering

MAT 194F CALCULUS I

I-5

3 - 2 10

Theory and applications of differential and integral calculus, limits, basic theorems, elementary functions.

MAT 195S CALCULUS II

I-5

3 - 1 7

Sequences, series, improper integrals, Taylor's theorem, differential equations, functions of several variables and partial derivatives.

MAT 280F CALCULUS

II-1,2,6

3 - 2 9

Partial differentiation, directional derivatives, tangent plane and normal line, maxima and minima, Lagrange multipliers, higher order derivatives, exact differentials. Multiple integrals, area, volume, moments, cylindrical and spherical coordinates, surface area. First and second order differential equations. Linear differential equations with constant coefficients, undetermined coefficients and variation of parameters, vibrations. (Exclusion: MAT 294S)

MAT 289S COMPLEX VARIABLES

II-5

3 - 1 8

Complex plane analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities, analytic continuation, contour integration, conformal mapping, and applications.

MAT 290F DIFFERENTIAL EQUATIONS

II-7

3 - 2 8

Linear ordinary differential equations and systems, series, transform and numerical solutions, nonlinear equations, introduction to partial differential equations.

MAT 293F CALCULUS

II-3,4,8

2 - 2 8

Functions, of several variables, partial differentiation, maximum and minimum problems, Taylor series. (Prerequisite: MAT 186F, MAT 187S)

MAT 294S CALCULUS AND DIFFERENTIAL EQUATIONS

II-4,8

2 - 2 8

Multiple integrals, area, volume, moments, cylindrical and spherical coordinates, surface area, line integrals. First and second order differential equations. Linear differential equations with constant coefficients. Linear systems. Matrix methods. Vibrations.

MAT 295F CALCULUS III

II-5

3 - 1 8

Convergence and uniform convergence, linear differential equations, coordinate transformations, multiple integrals, line and surface integrals, orthogonal functions.

DEPARTMENT OF MECHANICAL ENGINEERING

MEC 201S DYNAMICS I

II-3

3 - 1.5 8

Calculus of vectors. Kinematics of bodies in rectilinear and curvilinear translation, rotation, and general motion. Spacecraft orbits. Impulse, momentum and moment of linear momentum. Conservative systems. Work-energy relations. Dynamics of motion. Euler's equations. Gyroscopic mechanics. Plane motion. D'Alembert's principle. Virtual work. Introduction to generalized co-ordinates, degrees of freedom, Lagrange equations. Introduction to mechanical vibrations and balancing.

MEC 205F DYNAMICS

II-7

2 - 1 6

Kinematics of particles using Cartesian, space curve and cylindrical coordinates units. Dynamics of particles by momentum and energy methods. Kinematics and dynamics of rigid bodies. Mechanical vibrations. Text: Vector Mechanics for Engineers - Statics and Dynamics, Berr and Johnston, McGraw Hill, 1972.

MEC 211F MECHANICS OF SOLIDS I

II-3

3 1.5 1.5 8

Definition of stress and strain at a point. Linear stress strain (plane stress and plane strain). Principal stresses and strains; transformation of stress and strain; Mohr's method of analysis. Shearing stresses and deformations in circular shafts and thin walled hollow members. Bending and shearing stresses in beams; differential equations of equilibrium; singularity functions. Deflection of beams; buckling of columns. Thin shells of revolution. Properties of mechanical engineering materials.

MEC 212S MECHANICS OF SOLIDS II

II-3

3 - 1.5 8

Compound stresses, superposition. Experimental stress analysis methods (photoelasticity, strain gauging, brittle lacquer). Fatigue, yield and fracture criteria for engineering materials; stress concentrations. Design of members to meet strength requirements in engineering applications; torsion members, prismatic and non-prismatic beams, complex members, columns, thin shells and springs. Statically indeterminate problems. Energy methods of solution. Generalised equilibrium and compatibility relationships with application to thick cylindrical pressure vessels and rotating discs.

MEC 261F DIFFERENTIAL EQUATIONS

II-3

3 - 3 8

First-order equations. Second-order equations. Operator techniques. Systems of equations. Power series for variable-coefficient equations. Numerical techniques.

MEC 265S METROLOGY

II-3

2 1.5 1.5 8

Nature of experimental error, its minimization and response characteristics of physical systems. Emphasis is on probability, statistical analysis of experimental data, principles of quality control and design of experiments. Topics to be covered include evaluation of random processes and computer techniques for statistical treatment of continuous data; case studies and discussion of selected mechanical measurements.

MEC 303S VIBRATIONS

III-3

3 1 2 8

Systems modelling and analysis. Analysis of single degree of freedom systems. Various types of damping forces. Vibration isolation. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Analog and digital computer solution methods. Numerical methods of frequency analysis. Lagrange equations and Hamilton's principle. Energy methods. Vibration of strings, beams and plates.

MEC 315S STRESS ANALYSIS

III-5nt;

3 - 1 8

Definition of stress and strain at a point in a continuum; Derivation of equilibrium and compatibility relations; Use of stress functions and energy methods in stress analysis; Application to beams, plates, shells, pressure vessels and rotating discs; Fatigue failures; Introduction to finite element techniques: Experimental methods namely, photoelasticity, strain gauging and brittle coatings.

MEC 321F THERMODYNAMICS I

III-3

3 1.5 1.5 10

Thermodynamic states of simple systems; the fundamental relation of thermodynamics; the first law of thermodynamics; the entropy postulates; equilibrium; PVT-diagrams, equations of state, compressibility charts and steam tables; calculation of property changes, enthalpy, Helmholtz and Gibbs function, the Maxwell equations; applications of thermodynamics, cycles, reversibility; thermodynamics of phase changes, the Clapeyron equation, Gibbs phase rule; the fundamental structure of thermodynamics, the Euler equation, the Gibbs-Duhem equation and Legendre transformers.

MEC 322S THERMAL ENERGY CONVERSION

III-3

3 3 - 8

The application of thermodynamics to the analysis and design of heat engines, refrigerators and processes associated with useful energy transformations; engine and turbine cycles for vapours and gases; combustion processes; psychrometry and air conditioning; consequences of thermodynamic potential and availability considerations in direct energy conversion devices.

MEC 324S THERMAL ENVIRONMENT ENGINEERING

III-3, IV-3 (elective)

3 1.5 1.5 10

Psychrometrics, heating and cooling. Refrigeration including vapour compression, absorption and thermoelectric devices. Solar radiation. Design and applications to the control of environmental systems in residential, public and industrial buildings and processes. Computer-aided design procedures.

MEC 327F HEAT ENGINEERING

III-5a, 5nt

2 3 - 8

The concepts of engineering thermodynamics as they relate to energy conversion processes. Vapour power cycles using fossil and nuclear fuels. Gas power cycles, internal and external combustion engines and turbines. Gas compression, refrigeration and psychrometry. Combustion of fuels. Direct energy conversion and the potential for new systems.

MEC 341F FLUID MECHANICS I

III-3

3 1.5 1.5 10

Introductory concepts, fluid properties and definitions. Hydrostatics, Pascall and Euler theorems, hydrostatic stability. Kinematics and dynamics of the flow, Eulerian and Lagrangian coordinates, continuity, energy and momentum equations. Irrotational flow, velocity potential, stream function. Stress systems for a viscous fluid, Cauchy's equation, Navier-Stokes equations. Viscous, laminar flow. Turbulent flow, Reynolds equations. Boundary layer theory, internal and external flows.

MEC 349S TRANSPORT PHENOMENA

III-8;III5g (elective)

3 1.5 1.5 8

A study of the forces and motion produced by various fluid properties. Gravitational, viscous and inertial forces are considered in detail. Momentum, energy and continuity relation, boundary-layer approximation, turbulence, flow in pipes and around submerged bodies. Steady-state conduction in one dimension; extended surfaces; heat conduction with two or more independent variables; forced convection and dimensional analysis; heat transfer by free convection; radiant heat transfer; heat transfer by combined conduction and convection; heat transfer in liquid metals.

MEC 351F FLUID MECHANICS

III-1,III-2C (elective)

3 1.5 - 8

Introduction: fluid and flow characteristics dimensions and units. Fluid statics: fundamental equation, gravity and inertia action, engineering applications. Fundamentals of one-dimensional flow: conservation principles of mass, energy and momentum, applications to ideal-fluid flow. Dimensional analysis and similitude. Fundamental concepts of real fluid flow: laminar and turbulent flow, boundary layer concept, flow about immersed objects. Flow in closed conduits: flow development, friction loss, minor loss, typical pipe-flow problems. Flow in open channels: uniform flow, varied flow. Special topics of interest to civil engineers. Tutorials, films and experiments complementing lecture material.

MEC 354F FLUID MECHANICS

III-5c,5nt

3 3 - 8

A fundamental approach to the mechanics of fluid motion. Continuum concepts. Kinematics and dynamics of flow. Irrotational motion. Vorticity. Laminar flow solutions. Turbulent motions. Applications to conduit flow. Free surface waves. Fluid machinery.

MEC 357S CONTROL ENGINEERING

III-4

2 1 1 8

Introduction to the dynamic behaviour of linear systems. The feedback principles. Stability and response of linear control system. The convolution theory. Transfer functions of linear systems. Analysis and design of linear control system introduction to servomechanism technology for control system design. Problems and laboratory experiments will accompany the lectures. (Prerequisite: MAT 294S).

MEC 358S CONTROL SYSTEMS

III-5nt

3 1.5 1 8

Analysis and synthesis of linear feedback systems by frequency response methods and the root locus technique. Analysis of physical systems by state space techniques. Introduction to nonlinear and optimal control systems. Digital computer control. Multivariable feedback system design. Techniques will be illustrated by application to models of CANDU nuclear power stations.

MEC 363S ENGINEERING ANALYSIS II

III-3

2 - 1.5 8

Ordinary linear differential equations of second order, Sturm-Liouville theory and expansions in orthogonal functions. Higher-dimensional calculus and introduction to partial differential equations. Method of characteristics, separation of variables and integral transform methods of solution with application to problems of fluid flow, heat transfer and structural deformation.

MEC 371F ANALYSIS AND DESIGN OF MECHANISMS

III-3

3 - 3 10

Types of mechanisms; analysis and design to meet functional requirements of positioning, force application and energy transmission. Synthesis and analysis of linkages, cams, and gears. Hydraulic actuators. Design for dynamic loading and energy storage. Springs and flywheels. Load capacity of bearings and gears. Stress concentration factors.

MEC 375S ANALYSIS OF MACHINING PROCESSES

III-3, IV-3 (elective)

3 1.5 1.5 8

Machine tools and machining operations. Mechanics of machining. Temperatures in metal cutting. Tool wear, tool life. Cutting fluids. Machinability. Surface roughness. Economics of machining. Machine tool vibration. Numerical and adaptive control of machines tools. Modern machining : ultrasonic, electrochemical and electric-discharge machining.

MEC 376S ANALYSIS OF FORMING PROCESSES

III-3, IV-3 (elective)

3 1.5 1.5 8

Introduction to plasticity. Upper and lower bound theorems. The slip-line field theory. Hot and cold forming. Drawings. Tube making. Deep drawing. Extrusion. Rolling. Forging. Friction and lubrication in metalworking. Temperature distribution. Explosive forming. Powder metallurgy. Foundry processes. Polymer forming including compression, injection, blow and rotational moulding; vacuum forming. (NOT OFFERED 1976-77)

MEC 381S BIOMECHANICAL ENGINEERING

III-3, IV-3 (elective)

3 1.5 1.5 8

Aspects of fluid flow, surface chemistry, thermodynamics and solid mechanics related specifically to biomedical situations; case studies involving the above problems. (NOT OFFERED 1976-77)

MEC 413F MECHANICS OF SOLIDS III

IV-3

2 - 1.5 8

Stress and strain tensors and generalization of constitutive equations. Extension to orthotropic material constants. Equations of equilibrium and compatibility. Solution procedure using displacements and stress functions. Illustration of the theory by application to beams, plates, rotating discs, thick composite cylinders, torsion of non circular sections. Elastic instability. Fracture mechanics. Introduction to finite difference and finite element methods of solution.

MEC 426S STATISTICAL THERMODYNAMICS

III-5nt, 5p

3 1.5 - 10

The idea of ensemble averages is used to develop the expression for the fundamental relations of thermodynamics in terms of molecular properties; partition functions for the ideal monatomic crystal, the ideal monatomic gas and black body radiation are developed. A molecular interpretation of entropy is developed and fluctuations about an equilibrium state are discussed along the ergodic hypothesis and rate processes.

MEC 427S DIRECT ENERGY CONVERSION

IV-3 (elective)

2 1.5 1.5 8

Topics from non-equilibrium thermodynamics and the thermal properties of semi-conducting materials are discussed. Application of these ideas is made to energy conversion devices such as thermoelectric generators, solar cells and electrochemical cells. Alternative systems and energy storage problems are considered.

MEC 428F ENERGY CONVERSION

IV-5nt

3 3 - 8

The theory of fluctuations and the Onsager principle are discussed. Irreversible thermodynamics is developed and used to analyse direct energy conversion devices. Thermoelectric processes such as the Seebeck, Peltier, and Thomson effect are considered and systems such as fuel cells, thermoelectric, thermionic, and magnetohydrodynamic generators are analysed.

MEC 431F HFAT AND MASS TRANSFER

IV-3

3 1.5 1.5 8

Steady state and transient conduction; surface and gas radiation; convective heat and mass transfer under laminar and turbulent flow conditions in pipes, and over flat plates; free convection from plates and in plumes; dispersion of heat; boiling and condensation; application to the design of heat transfer equipment.

MEC 433S HEAT TRANSFER

IV-5nt

2 - 1 8

Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached.

MEC 443S APPLIED FLUID MECHANICS

IV-3

3 3 - 8

Study of one-dimensional gas dynamics encountered in Engineering practice including nozzle flows, friction, heating and normal shock waves. Water hammer and design procedures for alleviation, hydraulic transients in pipe system. Design principles and operational characteristics of flow machines, primarily turbo-machines. Lift and drag on submerged bodies and application to flow-induced vibrations. Dispersion of air pollution and concepts of pollution control.

MEC 444S ENVIRONMENTAL POLLUTION AND CONTROL

IV-3

2 1.5 1.5 8

Identification of serious environmental pollutants; analysis of short and long term effects upon the ecology; dispersion of contaminants in meteorological, limnological and oceanographic situations; techniques for tracing and measuring contaminant levels; control of effluent via precipitators, scrubbers, filters, etc. sociological and economic implications.

MEC 452S HYDRAULIC ENGINEERING

IV-1,2C (elective)

3 2 - 8

Review of flow principles. Techniques of field measurement. Open channel and closed circuit flow. Hydraulic structures and appurtenances, transitions, controls; dams; navigation works; methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering systems; analytical procedures, numerical methods and computer simulation. Systems analysis.

MEC 455F CONTROL SYSTEMS I

IV-3

3 1.5 1.5 8

Analysis and synthesis of linear feedback systems by frequency response methods and the rootlocus technique. Introductions to nonlinear control systems, the statespace technique, and digital computer control.

MEC 472S DESIGN

IV-3

2 - 3 8

Decision theory and methods of design synthesis will be presented and appraised in terms of the utility, the design variables and the constraining conditions imposed or associated with a given design. These concepts will be combined with various elements of mechanical engineering to illustrate design topics such as optimization, simulation and reliability. Several short design projects of this nature will be undertaken in which the student will be encouraged to utilize the computer and other related software as efficient and practical design tools.

MEC 499Y THESIS

IV-3

- - - 8, - - - 8

The thesis may consist of one of the following: 1. Group design projects: Large projects covering a broad range of mechanical engineering will be offered. The projects will refer to realistic situations and contribute to the solution of the design problem, i.e. individuals will specialize in the various aspects of the design. 2. Individual research and design projects: With the approval of the thesis coordinator and a supervising professor a student may perform original research, experimentation, or specialized design. 3. Interdisciplinary group design: The interdisciplinary group design course CED 401 may be taken in lieu of MEC 499. Full details of the thesis-project requirements are available on request from the Departmental Office.

MEC 1001F DYNAMICS II

IV-3 (elective)

2 1.5 1.5 8

Review of particles and rigid body kinematics and techniques for formulation of equations of motion; central force dynamics; gyrostatics; stability of dynamic systems; dynamic stresses, random excitation and dynamic test; special topics.

MEC 1050F PRINCIPLES OF MEASUREMENT

IV-3 (elective)

2 1.5 1.5 8

Design of experiment; uncertainty analysis and minimization of errors; discussion of physical principles underlying the design of mechanical, optical and electronic instruments and transducers; analogue and digital data recording and processing; data evaluation; random processes, spectra and correlation techniques.

MEC 1101F THERMODYNAMICS II

IV-3 (elective)

2 - 1.5 1.5 8

The postulatory approach to thermodynamics is developed. The conditions for equilibrium of systems under different constraints are considered. Systems undergoing phase transitions, elastic systems and the thermodynamics of surfaces are considered. The postulates are generalized to include non-equilibrium thermodynamics. Topics such as entropy production, generalized forces and fluxes, and the Onsager coefficients are discussed.

MEC 1201F FLUID MECHANICS II

IV-3 (elective)

2 1.5 1.5 8

Kinematics of fluid motion; equation of continuity, stream functions, circulation and vorticity. Dynamics of ideal flow fundamental equations, fluids at rest, filament flow, potential flow. Dynamics of real fluid flow: fundamental equations, similitude, exact solutions, creeping flow, boundary layers. Turbulent flow: general features, wall turbulence, free turbulence. Diffusion and convection problems.

MEC 1303S CONTROL SYSTEMS II

IV-3 (elective)

2 1.5 1.5 8

A detailed case study of modelling, analysis, and design of a electrohydraulic servo mechanism. The analysis and design of multivariable feedback systems based on state-space techniques. Case studies of (computer) control of multivariable systems, with emphasis on conventional and nuclear power generation.

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

MMS 100S INTRODUCTION TO METALS

I-1,2,3,4,5,6,7,8 (elective)

3 1.5 - 12

An introduction to the role of metals in the growth of the modern industrial society. The role of metal production in the Canadian economy, methods of extraction and fabrication of metals, and the effective utilization of metals will be discussed. In addition to laboratory experiments illustrating the determination of structure and properties of metals, the student will participate in a four-week project under the direct supervision of a professor. The project will enable the student to design and carry through studies of particular aspects of metal extraction and application.

The projects include:

Physical Metallurgy (Prof. Aust)

Solidification of Eutectic Alloys (Prof. Miller)

Fracture and Failure Analysis (Prof. Ramaswami)

Differential Thermal Analysis Prof. Toguri)

Beneficiation and Recovery of Iron Ores (Prof. Ross)

Production of Metallic Copper (Prof. McAndrew)

Freezing of Transparent Analogues of Metal Alloys (Prof. Rutter)

Electrolytic Recovery of Metals (Prof. Flengas)

Chemical Reactions in Iron and Steelmaking (Prof. McLean)

Staff in Metallurgy and Materials Science

MMS 201F STRUCTURE OF MATERIALS AND METALLOGRAPHY

II-8

2 3 1 8

A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed at various levels, viz. macrostructure, single phase microstructures, phase equilibria and binary phase diagrams, equilibrium and non-equilibrium two phase microstructures and crystal structure. Metallographic techniques for the determination of microstructure by optical, x-ray and electron microscopy are considered, as are quantitative metallography and the introductory principles of x-ray diffraction.

W.A. Miller

MMS 202F METALLURGICAL THERMODYNAMICS I

II-8

2 - 3 8

The physical - chemical properties of matter. Ideal and real gases, liquids, solids. Heat capacity theory and Debye's law. Calculations of enthalpy, entropy and of free energy for pure materials. First and second order transitions. Chemical equilibria. Heterogeneous reactions - Ellingham diagrams. Activities and other partial molar properties. Experimental techniques for thermodynamic measurements. (Prerequisite: MAT 186F).

S.N. Flengas

MMS 203S METALLURGICAL THERMODYNAMICS II

II-8

2 - 3 8

Chemical equilibria at high temperatures in extractive metallurgy. Slag-metal reactions - Order-disorder phenomena - Theory of solutions. Partial molar properties and Thermodynamic relationships in phase diagrams - Ternary solutions - Analytical and graphical solutions of the Gibbs-Duhem relationships. Standard States for the evaluation of partial molar properties and conversions. Solubility of gases in liquids. Phase diagram relationships in Metallurgical Systems. Binary and Ternary Systems.

S.N. Flengas, J.M. Toguri

MMS 204S MATERIALS CHEMISTRY

II-8

2 3 2 9

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle for ionic compounds and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding and physical properties of metals and alloys, and covalently - bonded solids. Inorganic and organic polymers. The laboratory deals with the instrumental analysis of ores, concentrates, slags and alloys.

C.B. Alcock, R.T. McAndrew

MMS 205S MATERIALS SCIENCE

II-8

2 - 2 7

A course on the structure and properties of plastics, glass and ceramics. The course discusses the relationship between the microstructure and physical and mechanical properties of non-metallic materials.

G.C. Weatherly

MMS 221F MATERIALS SCIENCE I

II-7

3 1.5 - 8

Part I deals with the structure of materials in terms of atomic bonding, crystal structure, defect structure and microstructure. Various processes that influence structure and properties of materials are discussed, such as diffusion, phase transformations, plastic deformation, fracture and the decomposition of super-saturated solid solutions. Other topics covered include the purification of semiconductor materials and the growth of single crystals, a discussion of selected useful metallic and ceramic materials, and a brief outline of their fabrication techniques. Part II deals with the macroscopic response of materials to mechanical loading with special reference to deformability, stability and strength of structural elements which are subjected to axial and biaxial stresses, flexure and torsion. Recommended Textbook: Ruoff, Introduction to Materials Science. (Exclusions:MMS 222F, 223S, 250S)

J.W. Rutter, R.H. Mills

MMS 222F MATERIALS SCIENCE AND ENGINEERING

II-4

2 1.5 1 8

The course deals with the basic principles necessary for the selection of engineering materials and for an understanding of their service behaviour. Fundamentals which provide a common basis for understanding the relationship between the structure and the properties of materials will be emphasized.

G.B. Craig

MMS 223S MATERIALS SCIENCE

II-3

3 1.5 - 8

The effect of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechanical properties of metallic and non-metallic materials, and composite materials. The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials. (Exclusions: MMS 221F, 222F, 250S)

K.T. Aust

MMS 224F INTRODUCTION TO MINERAL ENGINEERING

II-2

2 - 1 7

A broad survey of mineral engineering and its relation to geology and industry. The course deals with the preparation and processing of materials extracted from the earth such as sand, gravel, limestone and metallic ores. Operations treated include crushing and grinding, particle sizing and classification, liquid-solid separations, mineral concentration, hydrometallurgical (leaching, precipitation) and pyrometallurgical (roasting, sintering, smelting) operations. The course is illustrated through flowsheets of typical processes. Relevant aspects of mineralogy and slag-metal reactions are included. The course is intended to show the importance and relation of basic scientific and engineering principles to mineral technology and to provide a general familiarity with the subject to insure that subsequent specialized instruction is appreciated in its proper context.

H.U. Ross

MMS 226S MATERIALS CHEMISTRY

II-2

2 - 2 8

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle for ionic compounds and replacement reactions. Point defects, non-stoichiometry and conductivity. Covalent bonding, electronegativity and bond polarity. Inorganic chemistry of the major metallic elements.

C.B. Alcock

MMS 227S MATERIALS SCIENCE II

II-7

2 1.5 - 7

The magnetic, dielectric and conductive properties of materials, as related to their structure. Magnetic properties: dia-, para-, ferro-, antiferro-, and ferri-magnetic phenomena; magnetic domains and domain wall motion; "hard" and "soft" magnetic materials, magnetostriction. Dielectric materials; insulating properties, conduction mechanism, dielectric loss. Ferro-electric materials. Electrical conduction; temperature dependence effect of composition and structure on conductivity. Thermoelectric phenomena. Textbook: Rose et.al., The Structure and Prop. of Materials, Vol IV. (Prerequisite: MMS 221F, 222F, 223S, 250S)

U.M. Franklin

MMS 250S MATERIALS SCIENCE

II-5 (elective)

2 1.5 - 8

The effect of atomic structure, crystal structure, and microstructure on the physical, chemical and mechanical properties of solid materials. Representative examples of metals, ionic crystals, semiconductors, and inorganic compounds will be used to illustrate the principles of materials science. The laboratory experiments complement the lectures and demonstrate the methods and techniques of materials science. (Exclusions: MMS 221F, 222F, 223S)

B. Ramaswami

MMS 301F MINERAL PROCESSING I

III-8, 2B

2 3 1 8

The theory and practice of mineral beneficiation including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration by gravity, magnetic methods and flotation. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media. Experiments designed to illustrate the lecture material are carried out in the laboratory while related problems are studied in the tutorial periods.

H.U. Ross

MMS 302F ELECTROCHEMICAL AND KINETIC PROCESSES

III-8;IV-2B(elective)

2 - 4 8

Electrochemistry of solids, liquids and of high temperature systems - e.m.f. series - Fused salt electrochemical cells - Thermodynamics of imperfections and properties of ionic solids. Non-stoichiometric oxides, sulfides and carbides. Non-ionic conductivity mechanisms in solids. Fuel cells. Corrosion reactions in aqueous solutions and fused salts. Irreversible electrode reactions - Overvoltage. Kinetics of Heterogeneous reactions. Diffusion controlled processes. Pick's law of diffusion. Application of theory to metallurgical operations.

S.N. Flengas, J.M. Toguri

MMS 303F PHYSICAL METALLURGY

III-5m,8

3 3 - 8

An introduction to the fundamental basis of microstructure control stressing the importance of alloying, plastic deformation and annealing. The principles of solidification, crystal growth, and phase transformations in solids are considered in detail. (Prerequisite: MMS 201F, co-requisite: MMS 333F for those without MMS 201F)

U.M. Franklin, G.B. Craig, J.W. Rutter

MMS 304S PHYSICS OF METALS

III-5m,8

3 3 - 8

Plastic deformation and mechanical properties are discussed in terms of dislocation theory. The annealing processes of recovery, recrystallization and grain growth and the structure and properties of interfaces in materials are also considered. (Prerequisite MMS 303F)

K.T. Aust, W.A. Miller, B. Ramaswami

MMS 305S EXTRACTIVE METALLURGY I

III-8;III-5m (elective)

3 3 1 9

Non-ferrous Metallurgy: production of non-ferrous metals from their concentrates, with emphasis on metals produced in Canada; industrial flowsheets; refining of metals. Ferrous Metallurgy: principles of iron and steelmaking; thermodynamic and kinetic aspects; casting processes. Hydrometallurgy: introduction to theory and practice of metal production from ores and concentrates by chemical reaction in aqueous solutions. Extractive Metallurgy Laboratory: experiments related to the extraction of metals, and problems on heat and mass transfer.

R. McAndrew, A. McLean, H.U. Ross, J.M. Toguri

MMS 306F METALLURGICAL THERMODYNAMICS

III-5m

2 - 4 8

A study of chemical equilibria at high temperatures in metallurgy; slag-metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions; quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties.

S.N. Flengas, A. McLean

MMS 307S MATERIALS SCIENCE

III-5m

3 - - 8

The course discusses the relationship between the structure and properties of glasses, ceramics and polymers. Particular topics discussed are: phase diagrams in ceramic systems; structure of ceramics and glasses; glass-crystal transformation; structure of polymers diffusion; sintering of ceramics; elastic and plastic properties; viscous flow of glasses and polymers; fracture and thermal shock resistance.

G.C. Weatherly

MMS 308F CERAMIC MATERIALS

III-8

2 - 2 8

The practical application of ceramics in high temperature corrosive environments. Topics to be discussed include transport phenomena in ceramics, corrosion resistance, thermal shock resistance and mechanical strength. Ceramic coatings. Refractories.

C.B. Alcock, G.C. Weatherly

MMS 309F MINERALS EQUILIBRIA

III-2B

3 - 2 8

The methods and formulations of thermodynamics will be discussed on the basis of the three laws of thermodynamics. Phase equilibria diagrams will be presented for one, two and three component systems and equilibria criteria will be examined for simple mineral systems.

A. McLean, J.M. Toguri

MMS 310S EXTRACTIVE METALLURGY I

III-2B

3 3 1 9

Course MMS 305S with alternative laboratory assignments given with Course MMS 204S.

Staff in Metallurgy and Materials Science

MMS 311S SURFACE PROPERTIES OF MATERIALS

III-2B,8;III5m (elective)

2 - 1 7

Thermodynamic treatment of interfaces. Gibbs' adsorption theorem. Structure of liquid surfaces. Adsorption of gases on solids. Dispersion and electrokinetic phenomena.

S.N. Flengas

Topics related to surface properties applicable to mineral processing, such as wettability, contact angles, adsorption, flotation, coagulation, flocculation and dispersion. The Zeta potential of mineral particles in aqueous suspensions is examined in detail.

H.U. Ross

Surface tension, surface stress and surface free energy in solids. Broken bond model calculations of surface energy in solids. Internal interfaces in solids. Anisotropy. Equilibrium approach to processes such as grain growth, spheroidization, particle coarsening and sintering. Role of interfaces in phase transformation and fracture in solids.

A. Miller

MMS 312S METALLURGICAL CHEMISTRY

III 5m

3 - 4 9

Chemical equilibria at high temperatures in extractive metallurgy. Slag-metal reactions - Order-disorder phenomena - Theory of solutions. Partial molar properties and Thermodynamic relationships in phase diagrams - Ternary solutions - Analytical and graphical solutions of the Gibbs-Duhem relationships. Standard States for the evaluation of partial molar properties and conversions. Solubility of gases in liquids. Phase diagram relationships in Metallurgical Systems. Binary and Ternary Systems. Application of thermodynamic concepts to the theory of steelmaking.

S.N. Flengas, J.M. Toguri, A. McLean

MMS 333F STRUCTURE OF MATERIALS

III-5m

2 2 - 8

The structure of solids is treated in tutorial sessions and laboratory projects. Subjects covered include crystallography, phase equilibria, binary phase diagrams and microstructure of materials.

W.A. Miller

MMS 401F EXTRACTIVE METALLURGY II

IV-8; IV-2B,5m (elective)

3 1.5 1 8

Oxidation reactions, acid and basic steelmaking; transport considerations with reference to open hearth, converter, B.O.F. and electric furnace steelmaking; continuous steelmaking processes, the influence of vacuum treatment and argon rinsing in steelmaking. The refining of metals in terms of thermodynamic and kinetic principles. (Prerequisite: MMS 305S)

A. McLean, R.T. McAndrew, J.M. Toguri

MMS 402F SOLID STATE SCIENCE

IV-5m;8 (elective)

3 1.5 1 8

The course deals with relationships between crystal structure and the electronic and magnetic properties of solids, as well as the formation and stability of alloy phases and intermetallic compounds. The laboratory will be devoted mainly to x-ray and electron techniques applicable to both single crystals and polycrystalline materials. (Prerequisite: MMS 304S)

"M. Franklin, G.C. Weatherly

MMS 406S ADVANCED CHEMICAL METALLURGY

IV-5m,8

2 - 2 8

Selected topics related to the behaviour of metallic, ceramic, glass and metal-slag systems at high temperatures. Thermodynamic and transport properties of alloys and metallic oxides, carbides, silicides, etc. Corrosion reactions and vaporization processes. (Prerequisites: MMS 302F, MMS 401F)

S.N. Flengas, J.M. Toguri

MMS 407S METALLURGICAL SYSTEMS ANALYSIS

IV-2B;IV-8 (elective)

2 3 1 7

Through seminars, guest lecturers and field trips, the factors involved in process evaluation and operational decision making are highlighted and analyzed. The seminars include case studies of diverse activities in research and development, plant operations, marketing and financing. The laboratory work consists of one-week pilot plant project in conjunction with the Ontario Research Foundation at a time to be arranged.

R.T. McAndrew, A. McLean

MMS 408S MATERIALS ENGINEERING II

IV-8;IV5m (elective)

3 - - 8

The course deals mainly with deformation processing and joining methods. The topics covered include: stress-strain relationships in unidirectional and combined stress states, deformation zone geometry, friction and lubrication, plastic flow instability, textures, structural changes during processing, forging, rolling, wire-drawing, extrusion joining methods such as welding, defects in processed materials, and fracture.

G.B. Craig and B. Ramaswami

MMS 410F THEORY OF METALLURGICAL REACTIONS

IV-5m

2 - 2 8

Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and nonferrous metals, roasting, leaching and electro-winning are typical of the subjects discussed. (Prerequisite: MMS 306F)

J.M. Toguri

MMS 411S ADVANCED MATERIALS SCIENCE

IV-5m;8 (elective)

3 1.5 - 7

This course is offered to those students whose primary interest lies in the applied science aspects of materials. Recent developments in materials science are discussed in fields such as crystal growth, purification of materials, high-vacuum studies, preparation and characterization of clean surfaces, interfacial structures and properties, Auger emission and impurity segregation, environmental interactions. The laboratory work consists of research projects on contemporary problems in the field of materials science. (Prerequisite: MMS 402F)

K.T. Aust, J.W. Rutter

MMS 412S MINERAL PROCESSING II

IV-2B;IV-8 (elective)

2 1.5 - 7

This is a continuation of course 301F. Topics considered include particle size analysis and characterization; the motion of solids in fluids under laminar, transitional and turbulent conditions, rheology and the application of surface chemistry to minerals, flocculation and flotation. (Prerequisite: MMS 301F)

H." Ross

MMS 413F HYDROMETALLURGY

IV-2B; IV-6 (elective)

2 - 1 7

Theory and practice of metal production from ores and concentrates by chemical reaction in aqueous solution. Thermodynamic and kinetic fundamentals are emphasized. Topics covered include leaching, solution purification, metal precipitation, electrowinning and electrolytic refining. Examples of integrated process flowsheets are studied and compared to alternative pyrometallurgical processes.

R.T. McAndrew

MMS 414F MINERAL PROCESS DESIGN

IV-2B;IV-8 (elective)

2 3 - 8

This course deals with the design, operation and control of mineral processes including beneficiation, extraction, sampling and materials handling. Methods of estimating plant costs are studied.

P.T. McAndrew, H.U. Ross

MMS 416S NUCLEAR MATERIALS

IV5m,5nt (elective)

2 - 1 7

An introduction to structure-property relationship in nuclear materials such as uranium, zirconium, stainless steel, etc. Topics to be discussed include properties of liquid metals and corrosion in liquid environments; creep thermal cycling and thermal fatigue; radiation damage; nonstoichiometry in inorganic compounds; production and fabrication techniques of fuel rods and canning and cladding materials. Production and fabrication of uranium, thorium, zirconium and other reactor materials. (prerequisite: any Materials Science course)

MMS 417S APPLIED PHYSICAL METALLURGY

IV-5m,8 (elective)

3 - 1 7

This course deals with the application of scientific and engineering principles to materials selection and alloy design. The topics covered include: structure - property relationships in nuclear materials such as uranium, zirconium and stainless steel; methods of alloy design with special reference to applications for high and low temperature, radiation and corrosive environments; electronic, magnetic and composite materials; fracture mechanics and failure analysis.

Staff in Metallurgy and Materials Science

MMS 420S ADVANCED IRON AND STEELMAKING

IV-5m,8 (elective)

3 - - 7

This course deals with the application of the fundamentals of metallurgical chemistry to iron and steelmaking. Recent developments in solid state reduction processes, blast furnace practice, converter and arc-furnace steelmaking are discussed in the light of current publications. Deoxidation, inclusion control, gas injection, vacuum processes, ingot and continuous casting are also considered.

A. McLean and H.U. Ross

MMS 421S PHYSICAL CHEMISTRY OF IRON & STEELMAKING

IV-6 (elective)

2 - 1 7

Thermodynamics of molten iron alloys; gas-solid and slag-metal reactions in the blast furnace; alternative reduction processes; physical chemistry of steelmaking reactions; inclusion formation in steel; gas rinsing, vacuum processing, ingot and continuous casting.

H.U. Ross and A. McLean

MMS 432F MATERIALS ENGINEERING I

IV-8;IV-5m (elective)

3 1.5 1 8

The course deals with the methods of materials processing such as powder metallurgy and solidification processing. The topics covered include: the production and agglomeration of powders, the theory and practice of sintering, the application of powder processing methods to the production of refractory metals, cemented carbides and other materials, solidification, the structure of castings, segregation, defects in castings, casting processes and applications of the principles of fluid flow and heat transfer to materials processing.

K.T. Aust, J.W. Rutter

MMS 499Y THESIS

IV-8

- 6 - 6, - 12 - 12

The student chooses an experimental problem involving original work, which normally is related closely to the current research of a staff member. The student is asked to prepare a written report and two oral presentations describing the work.

Staff in Metallurgy and Materials Science

DEPARTMENT OF PHILOSOPHY

PHL 291F SCIENCE AND SOCIETY

2 - - 8

A philosophical examination of the role of the scientist, technologist, and engineer in contemporary society, including some of the following problems: pollution, and its control, war research, the "think tank", technocracy, nationalism.

PHL 292S SCIENCE AND PHILOSOPHY

2 - - 8

The advance of the physical, social, and life sciences has produced successive changes in concepts familiar to the ordinary man (space and time; cause and effect; man and animal; purpose, motive, freedom). The philosopher has attempted to work out the implications of these changes. This course will examine some of these attempts.

DEPARTMENT OF PHYSICS

PHY 180F ELEMENTS OF PHYSICS I (MECHANICS)

I-5

2 1.5 1 9

A study of the foundations of classical mechanics, including frames of reference, linear and angular motion of a particle, conservation of energy, linear and angular momentum. Detailed discussion of the harmonic oscillator, the inverse-square law force, and introduction to rigid body dynamics, all with examples from modern physics. Laboratory emphasizes general principles of experimentation; while working on selected and open-ended experiments. Text(s): A.P. French, Newtonian Mechanics

C.H. Chapman, B.P. Stoicheff

PHY 181S ELEMENTS OF PHYSICS II (THERMODYNAMICS AND STATISTICAL PHYSICS)

I-5

2 1.5 1 9

Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution. Text(s): SEARS, An Intro. to thermodynamics, the kinetic theory of gases, and statistical mechanics

C.H. Chapman, C.O. Hines

PHY 182S INTRODUCTION TO THERMAL PHYSICS AND WAVES

I-1,2,3,4,6,7,8 (elective)

3 1.5 - 8

An introductory course in Thermal Physics, Waves, Quanta, and Nuclei, intended to complement the Mechanics and Electricity offered to students in first year engineering. The course will range from classical thermodynamics, which is basic to many engineering processes through to selected topics in modern physics including nuclear energy. Lectures will be illustrated with demonstration experiments.

PHY 280F ELEMENTS OF PHYSICS III (FIELDS AND WAVES)

II-5

3 1.5 1 8

Principle of relativity, Lorentz transformations, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field. Electromagnetic field of uniformly moving charges. Electrostatic and magnetostatic fields. Maxwell's equations. Electromagnetic radiation and its generation. Synchrotron radiation. Interference of electromagnetic waves. Maxwell's equations in the presence of matter.

A.E. Litherland

PHY 281S ELEMENTS OF PHYSICS IV (QUANTUM PHYSICS)

II-5

2 1.5 1 8

Quantum concepts and the quantum aspect of electromagnetic radiation (photoelectric effect, Compton effect), wave particle duality (De Broglie hypothesis, wave packets, uncertainty principle), the Rutherford and Bohr atomic models; major emphasis on the mathematical understanding of the one dimensional Schrodinger equation; detailed solutions to a number of different potentials; the one dimensional harmonic oscillator; brief discussions of spectroscopy, nuclear, solid state, laser and high energy physics.

G. Luste

PHY 282F INTRODUCTION TO MODERN PHYSICS

II-8 (elective)

3 - - 8

The principles of modern physics with emphasis on applications to engineering. Specific topics include: relativity, quantum mechanics, nuclear physics and elementary particle physics. Reference: Blanchard et al. - Introduction to Modern Physics.

PHY 282S INTRODUCTION TO MODERN PHYSICS

II-1 (elective)

3 - - 8

The principles of modern physics with emphasis on applications to Engineering. Topics include: relativity; Rutherford/Bohr theory of the atom; atomic spectra; X-rays; Compton scattering; the photoelectric effect; particles and waves; black-body radiation; nuclear models; alpha decay; beta decay; fission and fusion and nuclear reactors; conservation laws of physics; astrophysics; some elementary solid state physics.

PHY 283F BASIC CLASSICAL AND MODERN PHYSICS

II-2, (elective)

3 - - 8

Superposition, reflection and transmission of sound waves; gravitational, electrostatic, magnetostatic fields and potentials; method of images; Ohm's law; polarization; A.C. circuits, concept of a phasor; magnetization; ferromagnetic properties of solids; the atom and the nucleus; unstable nuclei; natural radioactivity.

PHY 324H GEOPHYSICS LABORATORY I

IV-2a, 5g

3 - 4, - 3 - 4

A laboratory course in geophysical prospecting methods, to accompany PHY 338. Assignments are designed to demonstrate how theory is applied to field situations. The programme consists of weekly assignments that follow the lecture course. Co-requisite: PHY 338Y/PHY 443Y

PHY 326S MODERN PHYSICS LABORATORY

III-5p

- 6 - 8

Experiments of both a pure and applied nature are available in the areas of atomic, molecular, solid state, nuclear and particle physics. The experiments are open-ended; the student may spend more or less time on any particular experiment depending on his particular interest. The course provides a framework for a student to learn significant areas of modern physics on his own initiative. The laboratory is open five days a week. Demonstrators will be in the laboratory at the times shown in the timetable and available for consultation at other times. Registration at the Physics office first week of term. (Prerequisite: PHY 180F, 181S, 280F, 281S).

J. Prentice

PHY 334F INTRODUCTION TO SOLID STATE PHYSICS

III-5m; III-5p, IV5nt (elective)

2 - - 8

Introduction to the basic principles of solid state physics including; crystal structures and their determination using x-rays; propagation of waves in periodic structures; elastic waves, phonons, and thermal properties of solids; behaviour of electrons in crystalline solids and principal properties of metals, semi-conductors and insulators; selected features of superconductivity, magnetism and defects in solids. Text(s): R.A. Levi, Principles of Solid State Physics (Prerequisite: PHY 180F, 181S, 280F, 281S)

E. Fawcett

PHY 335F INTRODUCTION TO NUCLEAR PHYSICS

III-5nt;III-5p (elective)

2 - - 8

Important discoveries in nuclear and particle physics. Properties of the nucleus and of nuclei. The measurement of atomic masses; nuclear binding energies, binding energy and mass formulas, liquid drop and fission. Introduction to nuclear shell and collective models. Interaction of charged particles and uncharged particles with matter; particle detection, energy and momentum measurements. Radioactive decay phenomena: theory and experiment. Nuclear reactions and cross sections. Particle accelerators. (Prerequisite: PHY 180F, 181S, 281F, 281S)

D.J. Rowe

PHY 337S ELEMENTARY PARTICLE PHYSICS

III-5p (elective)

2 - - 8

This course presents a contemporary picture of the world of particle physics from a phenomenological rather than a theoretical point of view. The topics to be covered include the experimental method, types of interaction (weak, electromagnetic and strong), conservation laws and invariance principles, classification of particle states, and presently unsolved problems.

PHY 338Y EXPLORATION GEOPHYSICS

IV-2

2 - 1 6, 2 - 1 10

An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. References: Dobrin, Introduction to Geophysical Prospecting; Parasnis, Applied Geophysics.

G.D. Garland

PHY 344S ELASTICITY AND FLUID MECHANICS

III-5g

2 - - 8

A mathematical course in classical physics particularly for those interested in geophysics and meteorology. The elasticity part includes the definition and use of cartesian tensors to describe infinitesimal strains, stresses, and their relations. Fluid mechanics include fluid statics, continuity, Bernoulli, Euler, and Navier-Stokes equations, potential flow, vortex flow. Textbook: R.R. Long - Mechanics of Solids and Fluids; D.R.F. Harleman - Fluid Dynamics.

PHY 359S RADIOBIOLOGY

III 5p,IV-5nt (elective)

2 - - 8

This course is intended for students in Physics and Engineering Science and assumes no prerequisite courses in biology at the university level. Topics to be covered include the physics of the interaction of radiation with matter, the effects of radiation on molecules and cells, applications of ionizing radiation in radiotherapy and nuclear medicine, and problems of radiation protection including genetics and health hazards. The emphasis will be on the use of quantitative techniques for measuring biological effects.

A.M. Rauth

PHY 383F QUANTUM MECHANICS

III5nt,5p;III-5a (elective)

3 - - 8

This course builds on PHY 181S and PHY 281S, and will include: operator formalism and matrix methods, quantization of harmonic oscillator, one electron atom, and elementary perturbation theory.

PHY 384F THERMODYNAMICS AND STATISTICAL MECHANICS

III-7

3 - 1 8

This course begins with a treatment of the statistical features of simple magnetic spin systems and develops, with a minimum of formality, to the use of partition functions for these and more general systems, including the Fermi-Dirac distribution and the properties of the free-electron Fermi gas, as well as the treatment of noise and the Nyquist theorem. Also included are the concepts of spring temperature and maser action. The statistical development also leads to macroscopic thermodynamics, including: the laws of thermodynamics, heat engines (including heat pumps), the thermodynamics of systems in electric and magnetic fields, etc. A brief coverage of the physics of superconductors is also included. Textbook: C. Kittel, Thermal Physics.

P.D. Manchester

PHY 388F GEOPHYSICS LABORATORY

IV-5g

- 3 - 5

A laboratory course in geophysical prospecting methods to accompany PHY 443Y. Assignments are designed to demonstrate how theory is applied to field situations. The program commences with a 10 - day field camp held just before term begins. The cost of food and transportation will not exceed \$40 per student. During term the data taken in field camp may be interpreted as part of the sequence of assignments.

PHY 389S GEOPHYSICS LABORATORY

IV-5g

- 3 - 5

Continuation of PHY 388F.

PHY 422F GEOPHYSICAL TIME SERIES ANALYSIS LABORATORY

IV-5g

- 6 - 8

A laboratory concerned with mathematical and computational techniques for the analysis of discrete data series. Topics include Fourier, z and Laplace transforms in continuous and discrete representations, aliasing effects of sampling continuous functions, convolution and correlation, bandpass and optimum least squares, filtering and estimation of power spectra. The course is particularly relevant to geophysical data analysis. Reference: Kanasewich, Time Sequence Analysis in Geophysics.

R.C. Bailey

PHY 426F, PHY 429S QUANTUM PHYSICS LABORATORY I AND II

IV-5p (elective)

- 6 - 8, - 6 - 8

This laboratory is basically a continuation of PHY 326S. Experiments similar to those of PHY 326S are available but at a more advanced level. Some equipment of quality comparable to that used in contemporary research is available. Students have the opportunity to design and conduct experiments which have not previously been attempted in this laboratory. The laboratory is open five days a week. Demonstrators will be available in the lab at times shown in the timetable and available for consultation at other times. Registration at the Physics office first week of the term.

PHY 442Y PHYSICS OF THE EARTH

III-5g

2 - - 7, 2 - - 7

A course providing a physical background for the study of the interior of the earth, and the development of its surface features. Topics include seismic waves and the earth's structure, the gravitational field and the earth's mass distribution, geomagnetism, geochronology, and the mechanical and thermal properties of the earth's interior. Textbook: Garland, Physics of the Earth; Mantle, Core and Crust; Stacey, Physics of the Earth. (Prerequisite: Open only to III, IV-5G)

PHY 443Y THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV-5g

2 - - 6, 2 - - 6

The lectures stress the physical and mathematical theories of seismic, magnetic, electrical and gravitational methods. Considerable emphasis is placed on Fourier transform methods. Textbook: Grant and West, Interpretation Theory in Applied Geophysics; Griffiths and King, Applied Geophysics.

N. Edwards

PHY 452Y RELATIVITY THEORY

IV-5p (elective)

2 1 - 8, 2 1 - 8

The course provides a unified description of relativity theory. An up-to-date presentation of the present experimental comparisons of different theories of gravitation is also given. Topics covered include: special theory: principle of relativity, Lorentz-transformations, Minkowski space, Maxwell's equations. General theory: principle of equivalence, general covariance, tensor algebra, Einstein's equations, Schwarzschild solution, geodesics, experimental tests of gravitation theory, gravitational collapse, black holes, gravitational radiation, cosmology. References: Schrodinger, Space-Time Structure; Weinberg, Gravitation and Cosmology; Principles and Applications of the General Theory of Relativity; Misner, Thorne and Wheeler, Gravitation.

J. Moffat

PHY 482F, PHY483S QUANTUM THEORY I AND II

IV-5p (elective)

2 1 - 8, 2 1 - 8

Schrodinger equation, continuity equation, Ehrenfest theorem. Hilbert space, operators, eigenvalue problems, representations, unitary transformations. The harmonic oscillator, second quantization, coherent states. Scattering theory, partial waves, scattering operators. Approximation methods, variational principle, perturbation theory, golden rules, emission and absorption of radiation. Angular momenta, spin, CG coefficients. Identical particles, Pauli principle, exchange. Klein-Gordon and Dirac equations. References: Powell and Craseman - Quantum Mechanics; Messiah - Quantum Mechanics I and II; Schiff - Quantum Mechanics.

J. Van Kranendonk

PHY 484F, PHY 485S STATISTICAL MECHANICS I AND II

IV-5p (elective)

2 1 - 8, 2 1 - 8

Microcanonical, canonical and grand canonical distributions. Microscopic discussion of entropy, temperature and chemical potential. Ideal classical and quantum gases. Approach to equilibrium and irreversibility. Applications to magnetic systems, specific heats, phase transitions and fluctuation phenomena. Text(s) Landau & Lifschitz, Statistical Physics; Pathria, Statistical/Mechanics

L. Trainor

PHY 486F, PHY 487S NUCLEAR PHYSICS I AND II

IV-5nt,5p (elective)

2 1 - 8, 2 1 - 8

Nuclear forces and scattering. Neutron-proton scattering and pseudoscalar meson theory. Nuclear matter and mass formulae, properties of nuclei and their description in terms of shell and collective models, electromagnetic transitions in the nuclei, weak interactions, theory of nuclear reactions (a little) and the angular correlations of nuclear radiations. Text(s): Paul, Nuclear and Particle Physics; Segre, Nuclei and Particles (Prerequisite: PHY 382S)

A.E. Litherland

PHY 488F, PHY 489S HIGH ENERGY PHYSICS I AND II

IV-5p (elective)

2 1 - 8, 2 1 - 8

Introduction to concepts of high energy or particle physics. Topics include: particle accelerators and detectors, conservation laws and invariance principles in weak, electromagnetic and strong interactions, scattering theory, the production and decay of boson and baryon resonances, unitary symmetry and particle classification. (Prerequisite: PHY 382S)

R. Pugh

PHY 490F, PHY 491S SOLID STATE PHYSICS I AND II

IV-5p (elective)

2 1 - 8, 2 1 - 8

Crystal structures and binding energy; wave propagation in periodic structures, x-ray and neutron diffraction, electron and lattice waves Brillouin zones; phonons, specific heats, thermal properties of solids; free electron Fermi gas, energy bands, Fermi surface, electronic transport properties of metals and semiconductors; superconductivity; magnetism in solids; point defects, alloys dislocations. (Prerequisite: PHY 382S)

PHY 492F, PHY 493S MODERN OPTICS AND RADIATION I AND II

IV-5p (elective)

2 1 - 8, 2 1 - 8

Propagation of electromagnetic radiation; relativistic optics; polarization; coherence and interference; interferometry; diffraction; holography; optics of solids; nonlinear optics; optical spectra; Rayleigh, Brillouin and Raman scattering; magnetic resonance - NMR, EPR, NQR. Text: Fowles, Introduction to Modern Optics.

PHY 494F, PHY 495S GROUP THEORY AND ITS PHYSICAL APPLICATIONS I AND II

IV-5p (elective)

2 - - 8

Elements of group theory; group representations; basis vectors, basis functions and quantum mechanics; point groups and space groups; crystal field splitting of atomic energy levels; symmetry properties and statistical weights of molecular rotational levels; molecular vibrations and normal modes; molecular orbitals; energy bands in solids; Landau theory of second order phase transitions. References: Boardman, O'Connor and Young, Symmetry and its Applications in Science; Tinkham, Group Theory and Quantum Mechanics.

R.L. Armstrong

STATISTICS
(Department of Mathematics)

STA 282S PROBABILITY AND STATISTICS

II-8

2 - 2 8

Elements of probability theory. Binomial, Poisson and normal distributions. Sampling theory. Significance tests. Control charts. Least squares.

STA 287S PROBABILITY AND STATISTICS

II-5

3 - 1 8

Definition of probability; binomial, Poisson, and normal distributions; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance.

STA 291F PROBABILITY

II-4

2 - 2 8

Elements of probability. Random variables. Discrete and continuous distributions. Moments. Independence. Conditional probabilities. Theory of sampling. (Prerequisite: MAT 186F, MAT 187S)

STA 292S STATISTICS

II-4

2 - 2 8

A continuation of STA 291F. Tests of significance and confidence limits. Control charts. Introduction to the analysis of variance, design of experiments and regression. (Prerequisite: STA 291F)

ADDITIONAL COURSES

The courses listed below are not prescribed for any specific program, but are included in this section to bring them to the attention of interested students who may wish to choose one as an elective subject. The detailed course descriptions can be found in the appropriate calendar containing the listing of the departments offering the courses.

APS 401S	Social Impact of Technology		1 - 4 8
CHE 443Y	Organic Chemistry	2 3 - 8,	2 3 - 8
IND 426S	Organizational Behaviour		- 5 - 8
STA 347S	Probability and Applications		2 - 1 8

-
- Administrative Officers 7, 38
 Admission Requirements 40
 Admission, Applications and
 Procedures 40
 Aerospace Engineering 29, 111
 Annual Examinations 86
 Appeals 92
 Attendance 91

 Bachelor Degrees 9
 Bursaries 48

 Calendar of Events 5
 Chemical Engineering 21, 121
 Civil Engineering 12, 100
 Colleges 43
 Conduct of Students 93
 Cost of Attendance 85
 Curriculum 95

 Degrees 9
 Discipline 93

 Electrical Engineering 24, 123
 Employment Service 46
 Engineering Science 20, 110
 Enrolment, Summary of 10
 Examinations 86
 Fees 84

 Geological Engineering 14, 102
 Geology 181
 Graduate Studies 9

 High School Assistant's Certificate ... 10
 Holidays 5
 Housing Service 45

 Industrial Engineering 18, 108

 Loan Funds 48

 Mathematics 190
 Mechanical Engineering 16, 106
 Medals 48
 Metallurgy and Materials
 Science 27, 126

 Physics 208
 Practical Experience 134
 Prizes 48
 Professional Registration 10
 Programs 11

 Residence Accommodation 44

 Scholarships 48
 Special Students 10
 Survey Camp 154

The University of Toronto issues the following calendars and other publications concerning courses of instruction given by the University. Requests for calendars or information may be directed to the Office of Admissions of the University or to the Secretary of the particular Faculty, School or Institute.

ADMISSION INFORMATION—	Admission Awards Undergraduate Admission Handbook Undergraduate Admission Bulletin
APPLIED SCIENCE AND ENGINEERING—	Faculty of Applied Science and Engineering
ARCHITECTURE—	Department of Architecture Department of Landscape Architecture Department of Urban and Regional Planning
ARTS AND SCIENCE—	Faculty of Arts and Science— St. George Campus (including Woodsworth College) Scarborough College Calendar Erindale College Calendar
CONTINUING EDUCATION—	The School of Continuing Studies
DENTISTRY—	Faculty of Dentistry Division of Postgraduate Dental Education
EDUCATION—	Faculty of Education Institute of Child Study—descriptive brochure Graduate Degrees in Education*
FORESTRY—	Faculty of Forestry
GRADUATE STUDIES—	School of Graduate Studies
LAW—	Faculty of Law
LIBRARY SCIENCE—	Faculty of Library Science
MANAGEMENT STUDIES—	Faculty of Management Studies
MEDICINE—	Faculty of Medicine, Medical Course Department of Rehabilitation Medicine Division of Postgraduate Medical Education
MUSIC—	Faculty of Music Royal Conservatory of Music Year Book
NURSING—	Faculty of Nursing
PHARMACY—	Faculty of Pharmacy
PHYSICAL AND HEALTH EDUCATION—	School of Physical and Health Education
SOCIAL WORK—	Faculty of Social Work

*Write to: Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto, Ontario, M5S 1V6.

